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PC TECH JOURNAL®

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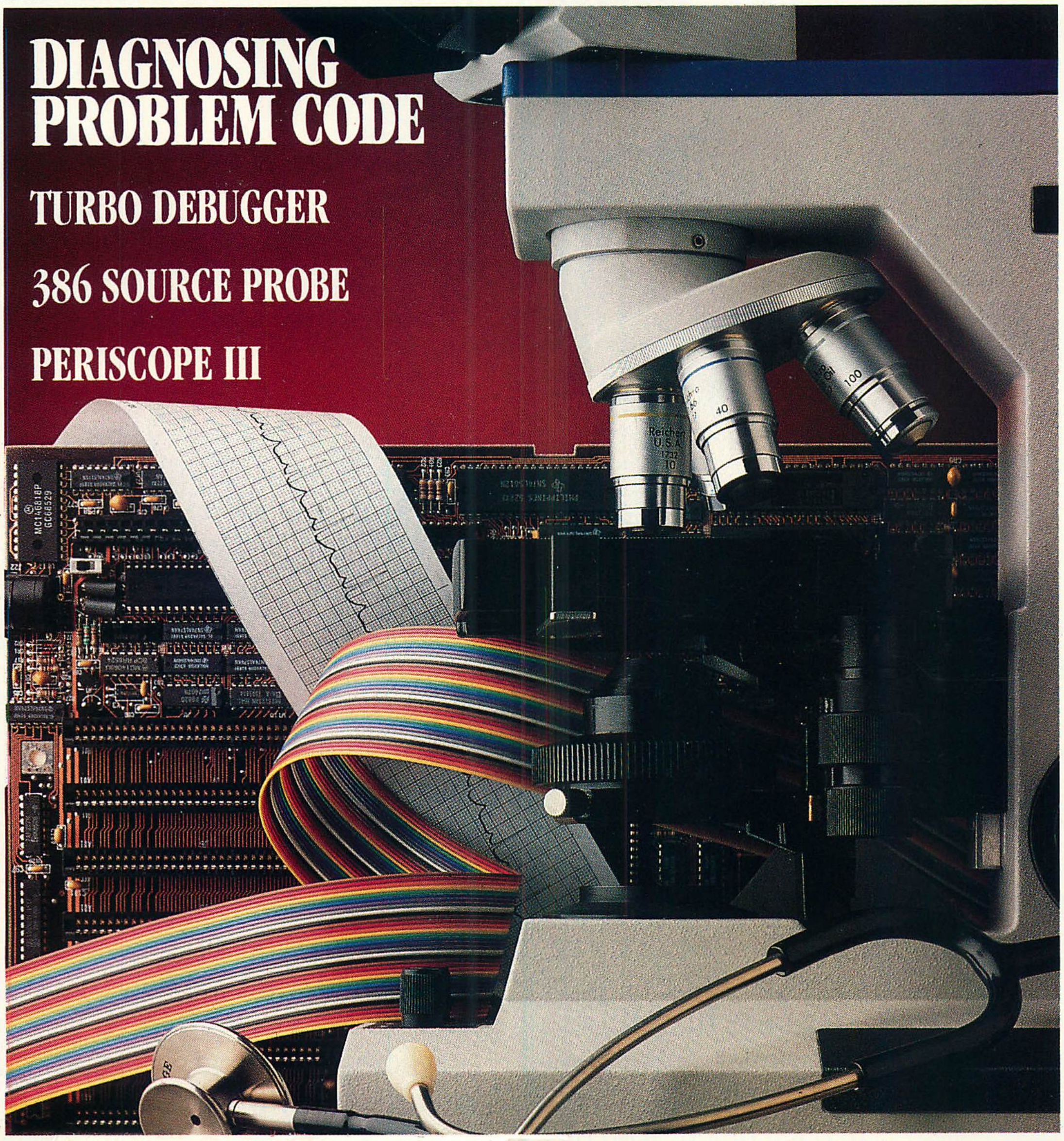

DIAGNOSING PROBLEM CODE

TURBO DEBUGGER

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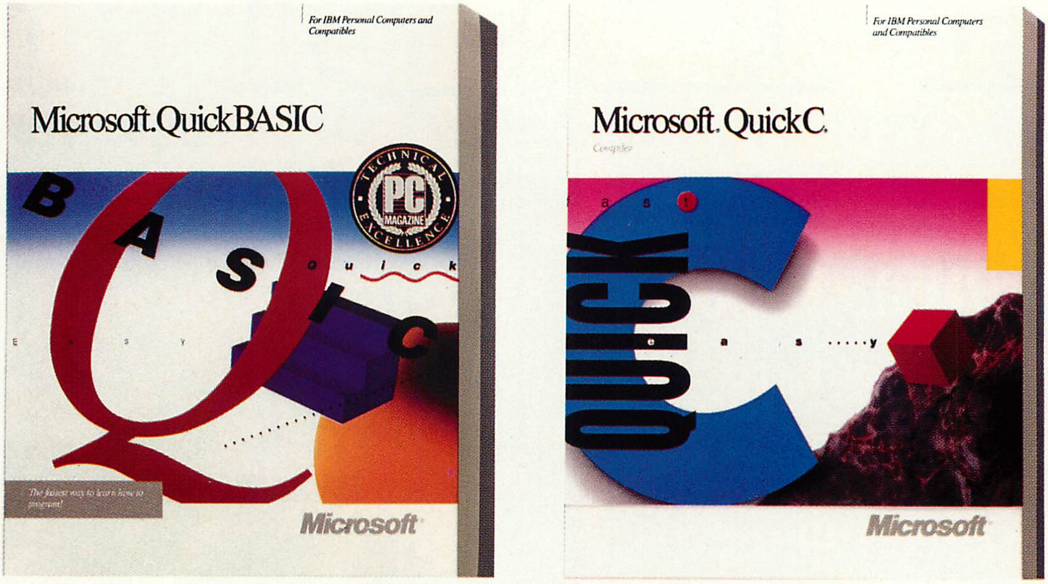
To each



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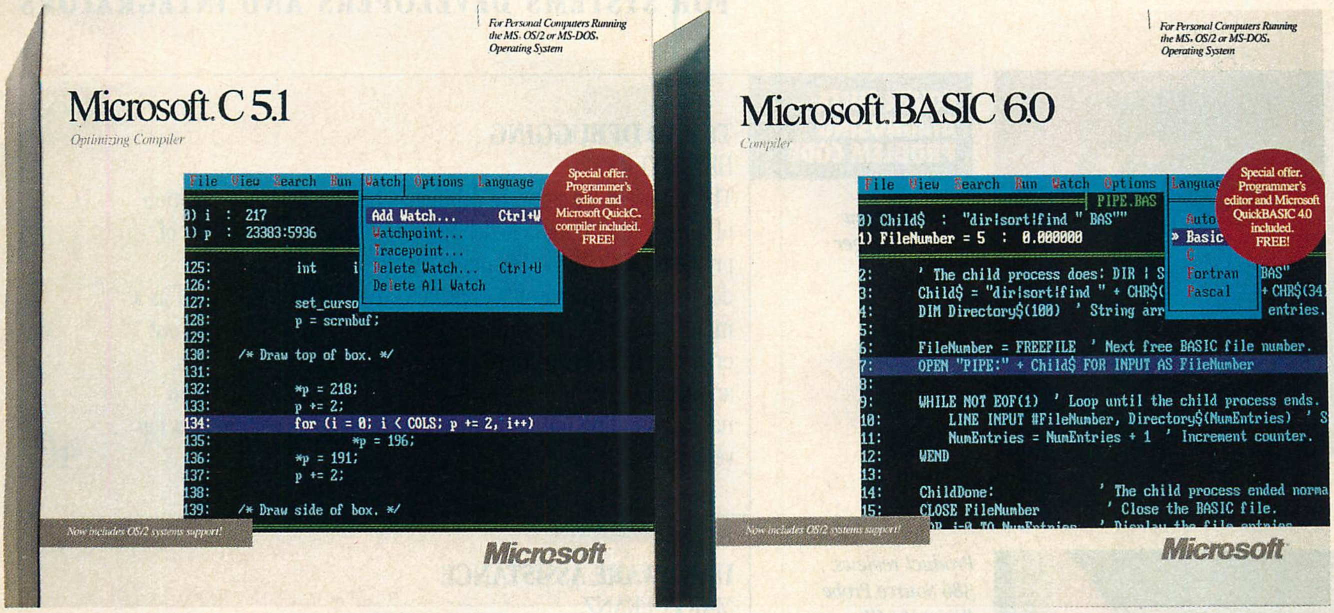

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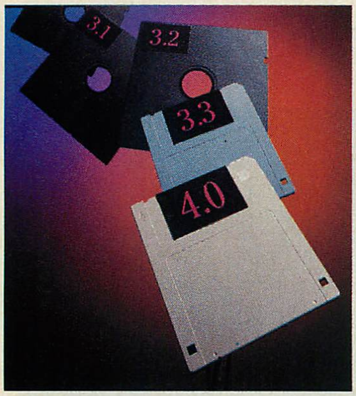

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COMPUTER SYSTEMS

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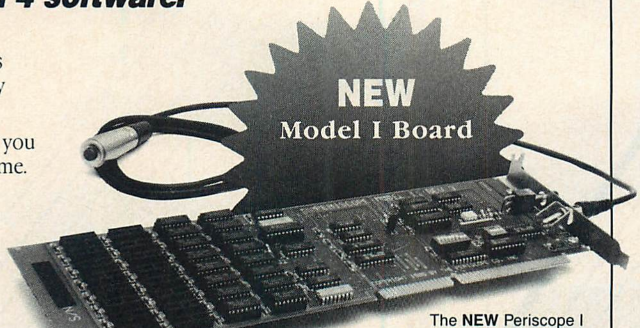
BPA

You No Longer Have to Share the Lower 640K With Your Debugger

Periscope I's new board uses ZERO memory in the lower 640K. Yet it has plenty of room to safely store all debugging information, like symbols, as well as the powerful Version 4 software.

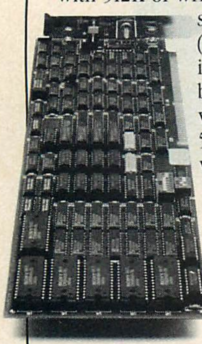


The **NEW** Periscope I memory board keeps all debugging information out of the lower 640K. Can be used in PCs, ATs, and 386s with both EGA/VGA and EMS boards installed. The Periscope break-out switch enables you to recover from a hung system. Included with Models I, II, and III.

Periscope's hardware adds the power to solve the really tough debugging problems.

The break-out switch lets you break into the system any time. You can track down a bug instantly, or just check what's going on, without having to reboot or power down and back up. That's really useful when your system hangs! The switch is included with Periscope I, Periscope II, and Periscope III.

Periscope I has a **NEW** board with 512K of write-protected RAM, user-expandable to 1MB, for the Periscope software, symbol tables, and all related debugging information. Normal DOS memory (the lower 640K) is thus totally freed up for your application, and Periscope is protected from being overwritten by a run-away program. The new board's footprint is only 32K, so you can use it in PC, AT, and 386 systems with EGA/VGA and EMS boards installed (not possible with the previous 56K board). It can also be used with Periscope III to provide additional write-protected memory.



Periscope III has a board with 64K of write-protected RAM to store the Periscope software and as much additional information as will fit. AND...

The Periscope III board adds another powerful dimension to your debugging. Its hardware breakpoints and real-time trace buffer let you track down bugs that a software-oriented debugger would take too long to find, or can't find at all!

The Periscope III hardware-breakpoint board captures information in real-time, so you'll find bugs that can't be found with a software-based debugger.

Periscope's software is solid, comprehensive, and flexible.

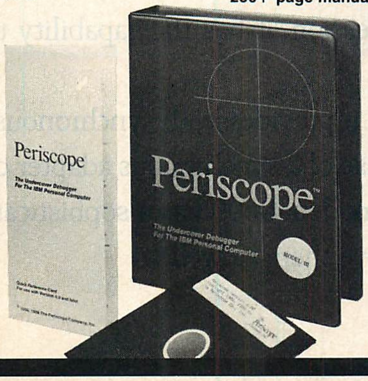
It helps you debug just about any kind of program you can write . . . thoroughly and efficiently.

Periscope's the answer for debugging device-drivers, memory-resident, non-DOS, and interrupt-driven programs. Periscope works with any language, and provides source and/or symbol support for programs written in high-level languages and assembler.

David Nanian, President of Underware, Inc. (of BRIEF fame) says this about the new Periscope Version 4:

"Periscope has always been an unbelievable assembler-level debugger. Version 4 has turned it into a terrific source-level debugger as well. Aside from major enhancements like the source-level improvements, all the little changes make a really big difference, too. For instance, symbol lookups and disassemblies are noticeably faster, and highlighting the registers that have changed really makes life easier. Once again, Periscope industry standard for debugg

Periscope software & 250+ page manual



What's New in Periscope Version 4:

- View local symbols from Microsoft C (Version 5)
- Debug Microsoft windows applications
- Set breakpoints in PLINK overlays
- Improved source-level support
- Monitor variables in a Watch window
- 80386 debug register support
- Debug using a dumb terminal
- PS/2 watchdog timer support
- Use mixed-case symbols
- Set breakpoints on values of Flags
- Much more!

- **Periscope I** includes a **NEW** full-length board with 512K of write-protected RAM; (user-expandable to 1MB); break-out switch; software and manual for $795.
- **Periscope II** includes break-out switch; software and manual for $175.
- **Periscope II-X** includes software and manual (no hardware) for $145.
- **Periscope III** includes a full-length board with 64K of write-protected RAM, hardware breakpoints and real-time trace buffer; break-out switch; software and manual. Periscope III for machines running up to 10 MHz with one wait-state is $1395. Plus the new Model I board, $1995.

Due to the volatility of RAM costs, prices on board models are subject to change without notice.

REQUIREMENTS: IBM PC, XT, AT, PS/2, 80386 or close compatible (Periscope III requires hardware as well as software compatibility, thus will not work on PS/2 or 80386 systems); DOS 2.0 or later; 64K available memory (128K at installation time); one disk drive; an 80-column monitor.

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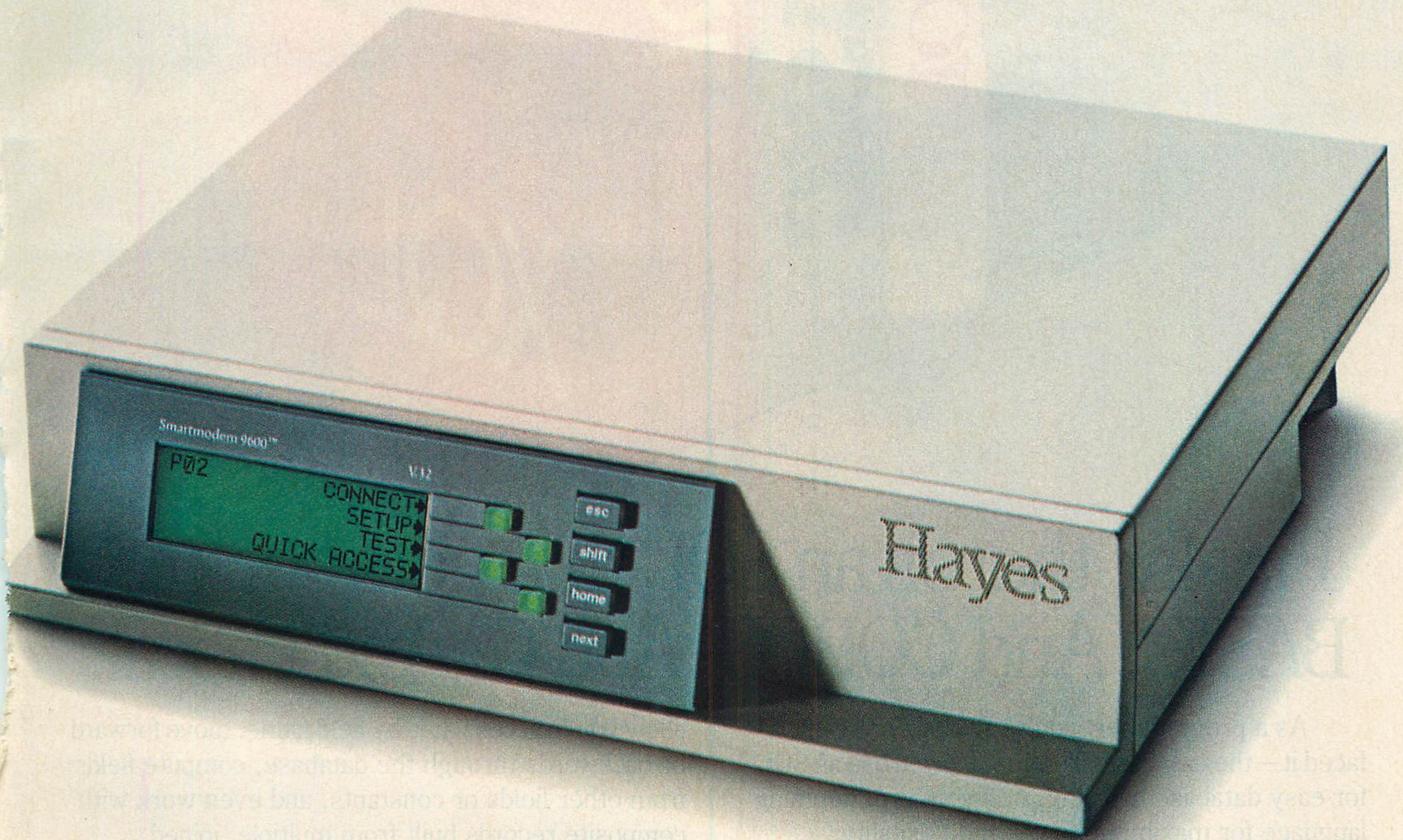
The Hayes V-series Smartmodem 9600 has a sophistication that not only sets it apart from other PC modems, but above them as well.

SOPHISTICATED SIMPLICITY FOR THE MAINFRAME WORLD.



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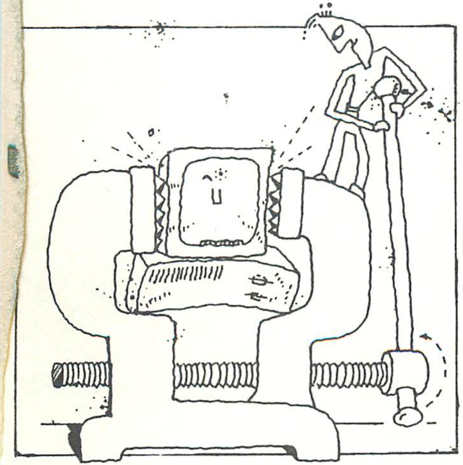

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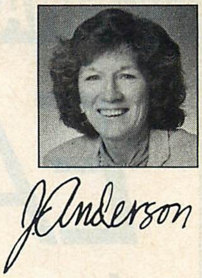

Tools for the New Year

Last year proved to be one of uncertainty and anticipation, but 1989 will likely be a busy one for developers.

The changing of the calendar year is a time to take stock of where we've been and where we're going. For developers, 1988 was a year of waiting and experimenting, but 1989 promises to be a year of activity.

Throughout most of 1988, developers waited for IBM and Microsoft to deliver their promised Presentation Manager, LAN Manager, and database servers. While waiting, developers experimented with OS/2 and an unstable, early release of Presentation Manager, and they speculated about whether it was better to develop for version 1.0 of OS/2, wait for the delivery of Presentation Manager, convert to Unix, or just stay with DOS.

In the fourth quarter of 1988, IBM and Microsoft delivered those essential parts of the operating system (graphics user interface, LAN support, and database server) that form the enabling technology for a new generation of applications. Before they can be developed, however, we need to see a new generation of development tools. The next round of tools must concentrate on facilitating program design and expediting code generation. These new tools, which should appear in 1989, will be similar to traditional mainframe CASE tools, but with a PC twist.

Of the many CASE tools pouring into the PC market, those that survive will go beyond structured analysis and design, adding two important features: prototyping and generation of C code. Prototyping helps developers work effectively with end users to design applications that satisfy the end users' needs; the C capability is important because it is the language of choice for microcomputer development.

Also important will be a new breed of tools that I call interface generators. In contrast to screen generators, which allow a developer to build a bounce-bar menu or to paint a text-based data-entry form highlighted with colors and boxes, interface generators will build a Presentation Manager-style user interface interactively. The developer will be able to create radio buttons, dialog boxes, and pull-down menus without the aggravation of writing extensive code.

Several companies are already demonstrating these interfaces, including Microrim in its upcoming Presentation Manager version of R:BASE, and Gupta Technologies in SQL Windows. In addition, SofTools has announced CASE:W for Microsoft Windows development, to be followed in the first quarter of 1989 by CASE:PM for Presentation Manager development.

Portability is foremost in many developers' minds as they race to adapt their DOS and Windows products to the emerging troika of operating system platforms: OS/2, Unix, and the Macintosh. These developers need a common system interface library—a standard set of system-independent function calls that are implemented on all three platforms. Watch for tools that handle at least two of these three platforms to appear this year.

Apart from the user interface, the biggest impact of this new wave of enabling technology will be felt in data management. OS/2's multitasking and LAN Manager's named pipes will make possible an effective scheme for multiuser data management on a network, a feat the industry has been attempting for several years with only a modicum of success. Under OS/2, data management tasks will be split between a server and a front end communicating via Structured Query Language (SQL).

A number of companies have announced server and front-end pairs, and several more have announced front ends only. These independent front ends are declaring support for a variety of servers, because it is anybody's call as to which, if any, of these servers will dominate. The most popular servers being supported by the independent front ends are the Microsoft/Ashton-Tate/Sybase SQL Server, Novell's XQL, IBM's OS/2 Extended Edition Database Manager, and Oracle.

Some traditional mainframe applications are being redesigned into server and front-end cooperative architectures as well. The mainframe will act as data repository and watchguard, while the PC will provide the user interface and perform initial data validation with improved response time.

IBM's High-level Language Application Program Interface (HLLAPI) is the first step toward cooperative proces-

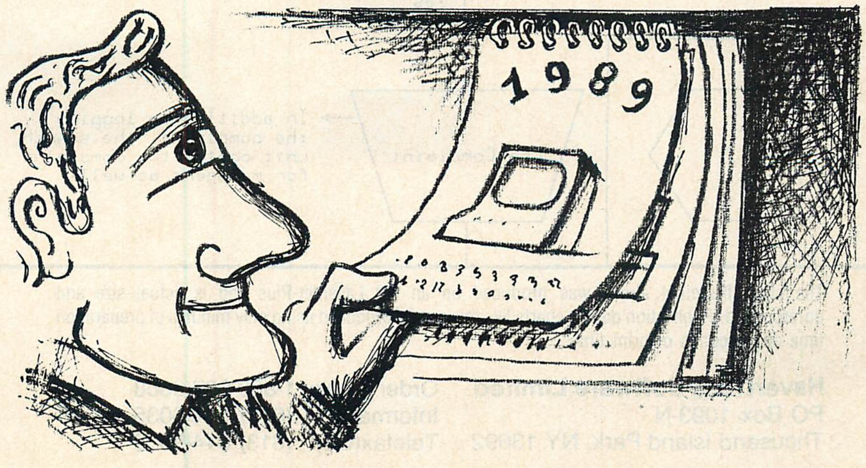

ILLUSTRATION • MACIEK ALBRECHT

sing, although the more appropriate term in HLLAPI's case may be *uncooperative processing*. With HLLAPI, a program can intercept data streams from the mainframe and selectively pass information between the PC and mainframe without any modifications to the mainframe application. (See "The High Road to Host Connectivity," Michael Triner, this issue, p. 84.)

Multisoft adds a level of cooperation with its InFront product, which allows field-by-field validation on the PC. Multisoft's Software Distribution Facility, which runs on the mainframe, ensures at logon that each PC has the latest version of the InFront application.

DEBUGGING TOOLS

Despite these advanced tools, developers may still find that their applications do not run the first time—whether it is because of program errors or incompatibilities with other hardware or software. Fortunately, good debugging tools are available now. In this issue, we look at the state of the art in software and hardware-assisted debuggers.

The first article of our cover suite ("Turbo Debugging," Ben Myers, p. 46), looks at Borland's new Turbo Debugger, which takes the example set by Microsoft's CodeView and adds remote debugging and 386 virtual-mode support. In a sidebar, executive editor David Methvin reports on how the OS/2 version of CodeView manages the debugging of multiple tasks.

In the second article, "Hardware Assistance" (p. 58), Marty Franz examines Atron's 386 Source Probe and The Periscope Company's Periscope III. Supplementing the cover suite, technical editor Ted Mirecki explains the debug registers of the 386 and demonstrates how to interface them to an existing debugger (Tech Notebook, p. 121).

THE BEST TOOL

Although good debugging tools are plentiful, we should not forget that the most important tool in diagnosing and correcting problems is still the developer. Before any debugger is put into service, much preliminary thinking and sleuthing has to occur.

We would like to hear about your debugging methods. How do you go about finding and correcting bugs in a program? If you have a special debugging technique, please fill out the reader opinion card bound in front of this editorial. We will report on the best techniques we receive in a future issue.

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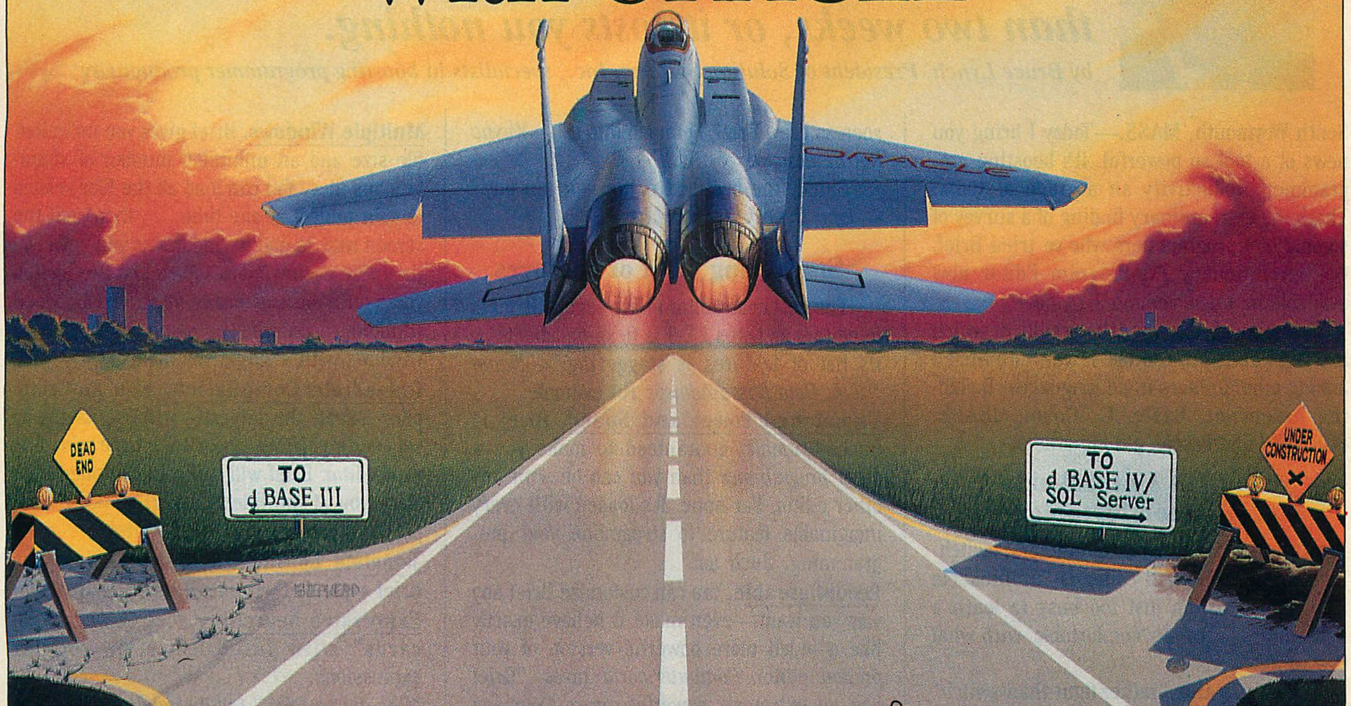

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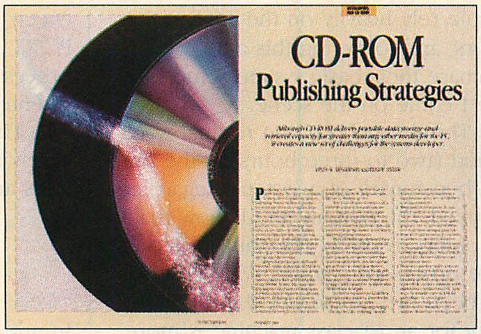
LETTERS



ADVANCING CD-ROM

Thank you for an excellent review of CD-ROM technology, application-development tools, and search-software design considerations in your October issue ("CD-ROM Publishing Strategies," Linda W. Helgerson and Fred P. Meyer, p. 52, and "In Search of CD-ROM Data," Linda W. Helgerson and Harvey G. Martens, p. 66). We at Discovery Systems, one of the manufacturers of CD-ROMs, are pleased to read articles that so thoroughly address the major considerations involved with the development of CD-ROM applications.

With the rapid improvements being made in this industry, it is sometimes difficult to gather all the latest facts. Such is the case with mastering costs, which were presented in the article as being in the $3,000 to $10,000 range. We now offer mastering at a cost from $1,500 for five-day turnaround to $3,000 for one-day turnaround. Replication costs are $2 per disk, with no minimum unit volume.

Jeffrey M. Wilkins, president
Discovery Systems
Dublin, OH

MKS RCS REVISITED

We were pleased to see our revision control system (MKS RCS 4.2c) reviewed (Product Watch, Jim Vallino, October, 1988, p. 131). I would, however, like to clear up two issues that may have left your readers confused.

The first issue concerns Unix compatibility. Mr. Vallino states, "When an archive file was transferred from DOS to Unix, all RCS operations on that particular implementation would not work because the Access statement was expected on the second line of the archive file." Newer versions of Unix RCS now include the Branch key word in the second line and move Access to the third line. Version 2.0 RCS files do not understand the Branch key word, but versions 3.0 and 4.0, from which MKS RCS is derived, do. For example, the newer version of RCS is delivered with version 4.3 of BSD Unix.

The second issue concerns MKS RCS networking capabilities. The review points out that our software does not have PC network capabilities. This contradicts an earlier mention by Mr. Vallino of some of the software's network capabilities.

MKS RCS allows projects to work over a network, using the DOS NETBIOS file-sharing mechanisms for RCS files to prevent simultaneous updates. In addition, RCS can optionally query the Novell network for user ID information. In-house, our personnel regularly use MKS RCS with PC/NFS and Novell NetWare. We offer attractive network pricing and sell this product mostly for network use.

Mike Brookbank
Mortice Kern Systems Inc.
Waterloo, Ontario, Canada

Thank you for clarification of the compatibility problem with different versions of RCS. Developers planning to interchange files with a Unix system should ensure that they have the newest Unix RCS version. The statement that MKS RCS does not have networking capabilities is indeed incorrect. When Mr. Vallino examined the documentation, he found no mention of network capabilities. When we called Mortice Kern Systems to verify the statement, an MKS technical support person explained the undocumented features (RCSDIR and ***network=novell****) for working with networks. We verified the features on our in-house network and added them to the review. Unfortunately, the mention at the end of the article was not updated.* —DWM

WHO'S DRIVING?

I was interested to read the comments about the *MS-DOS Encyclopedia* (Letters, Ben Myers, October 1988, p. 15). In the course of complaining about undocumented MS-DOS function calls, Mr. Myers says, "Useful function calls for writers of device drivers include Get Drive Parameter Block (32H), Get DOS List of Lists (52H), and Translate BPB (53H)." This statement reveals that he has never written such a driver himself. One of the most important constraints on an MS-DOS device driver is that it may not make any INT 21H calls at all, except for a very restricted subset during its initialization.

Ray G. Duncan, general editor
The MS-DOS Encyclopedia
Microsoft Press

In Mr. Myers' letter, he clearly states that the reason he was reading the MS-DOS Encyclopedia *was to learn how to write a device driver, a feat he had never attempted. We at* PC Tech Journal, *however, know about the restrictions against using INT 21H calls from within device drivers and should have caught the error.* —JA

IF THE CHIP FITS

The following two letters were sent as additions to the reader opinion card (bound in the September 1988 issue) that asked the question, "Do your applications really need a 25-MHz, 386 machine?" (See Professional Viewpoint, December 1988, p. 160, for an overview of responses.) —JA

I was dumbfounded by your question—probably the most intelligent one I have heard in months.

I am a nuts-and-bolts business programmer, not a world-class programmer. All of our applications are for the PC, and for us, the big mainframes do not exist. The vast majority of our customers are business people with a problem, and that problem is too much data, in the wrong format, in the wrong place, for use on a system that no longer works. Most of these business

people rely heavily on the advice of others, and following this advice, they purchase their basic system setup before I come on the scene.

The throughput in a normal work period (two to three hours) is the only real benchmark of a system. Regardless of speed, the bottom line is how many customers, records, files, and orders were processed—and at what cost. It has been my experience that $3,500 spent for an AT-class machine is more effective than $8,500 for a 386, based on observed work completed.

It would be silly to deny that the 386 has valid target applications. In many cases, the basic problem in a system is not enough speed—plain and simple. Many networks do blow away an 8086 and make the 286 look like a PC or PC/XT. In the appropriate situation, the 386 is the miracle cure. Surely, there are people who have a 32-bit nonmainframe application problem for which they need a 386.

Many times I find PCs with a $500 to $900 math coprocessor installed, when the customer uses only dBASE III PLUS or WordStar; or 384KB of extended memory, RAMDRIVE.SYS (not installed in CONFIG.SYS), and a $1,200 RAMpage board installed. I have found CMOS clocks with an extra backup battery. (Note that a lithium battery has a shelf life and an installed life that exceeds alkaline batteries by two years; thus, the backup will die long before the main batteries will.) Many customers have 40MB hard disks that are partitioned into two or more logical drives; because only the first logical drive is used, the customer is unaware of the others. A/B switching boxes are sometimes sold to customers who do not know that they already have two parallel adapters. The list goes on.

These customers could use an uninterruptible power supply more than a coprocessor. They could use a 5-picosecond surge suppressor more than an extra backup battery. Why don't the sales people suggest these items?

When I examine the programming business, I find that the most common task of the largest workstation is finding records in a relational database that is indexed. Generally, these files are too large to be loaded into RAM and require heavy disk access. A customer is rarely willing to buy an Intel Above Board card. Most 386 systems show various computing indexes to prove that they are fast, but the same speed utilities indicate that the attached hard disk is actually slower—usually between 1.5 and 2.5 times the speed of a PC/XT 10MB hard disk. A system cannot process any faster than its slowest port of entry or exit.

Thank you for this forum. I sincerely appreciate the great job you folks are doing at *PC Tech Journal.*

Peter T. Burke
CounterPoint Software Inc.
Pasadena, TX

In answer to your question, "Do your applications really need a 25-MHz, 386 machine?", my answer is a resounding "sometimes." Certainly, no simple word processing application requires that speed or power; for many applications (both in-house and off-the-shelf), however, the speed and power are critical.

I find that a common misconception in the computer press, and even among many computer professionals, involves comparing the PC with older mainframes. We have all heard the remark that a 386-based PC has as much power as IBM 370 models of 10 years ago. An immediate reaction is to ask why anyone needs that kind of computing power. Very few people do, yet I doubt that any firm using 10-year-old IBM mainframes will part with them for a new 386-based machine. The machines were built with different purposes in mind; comparing the two is like comparing apples and oranges.

With that said, remember that PC stands for personal computer. Ease of operation, even if not always achieved, is certainly a mandate of the PC. Along with this is the ability to get answers and reach solutions quickly. Our mainframe users are accustomed to waiting hours for reports to be run, days for tapes to be cut, and months (years?) for projects to be completed. Our PC users (who are usually the same as our mainframe users), on the other hand, are accustomed to quick turnaround times for reports and projects.

Furthermore, despite the ongoing complaint involving training costs on the PC, would anyone claim that the PC is more difficult to use than a mainframe, and even in some cases, a minicomputer? Certainly not, if you take into consideration the level of control and flexibility the PC offers.

If we accept that PCs should be as easy to use as possible and provide quick turnaround on any task, the need for the fastest possible machine becomes apparent. As any programmer will attest, quite a bit of overhead is inherent to providing an easy-to-use interface. The trend toward a graphics

user interface will only increase this overhead and probably require 386-based machines. Also, as more work is off-loaded from the mainframe, the need to manipulate larger files will become imperative. Again, we see a requirement for a machine based on a fast 80386 (or 68020). For our firm, many of these needs exist now and have only been awaiting machines powerful enough to address them.

Finally, the trend toward more sophisticated operating systems, with better memory, task, and device management, requires a machine with the hardware support for these features provided on the chip. Do we need 25-MHz, 386-based machines for some of our applications? Only until the 50-MHz, 486-based machines come out.

Anthony DeVito
Pershing
New York, NY

REVEALING FILE STRUCTURES

I agree completely with the letter to the editor from Evan P. Provisor ("Free the Data Structures," p. 15) published in the September 1988 issue of your fine magazine. I, too, have come upon many instances, both in my free-lance consultation service and my corporate user community, where knowing the file structure would have saved many hours of grief to resolve an otherwise minor problem.

By providing these facts (as part of the documentation), the user or support person can not only do time-saving recovery operations, but can also write custom utilities to use on the data. As Dr. Provisor points out, this would not cripple the marketing advantage of a product; it may actually increase the market share because third-party products could increase the value of owning such a program.

An alternative to revealing the file structures is to have standardized file structures for the various categories of programmed systems. One file structure for word processing would allow any vendor's program to recognize the formatting codes and style sheets of a document from another program. Another one for database processing would allow the data in any file to be manipulated by all file-management programs. This would indeed hurt market share for some, as the more powerful products that are easy to learn and use would capture the largest number of users eager to buy into this "revolutionary" idea.

Maybe someday the software suppliers to the microcomputer industry will recognize the advantages of this manner of doing business. With OS/2, either SQL Server or the built-in database features of the Extended Edition will provide this capability, and the vendors will lean more in this direction. Until then, microcomputer users and support people will suffer.

Richard Curry
Columbus, OH

PC TECH JOURNAL IN POLAND

I am an electrical engineer, graduated in 1982 from the Warsaw Polytechnic. Since then, I have worked for a large chemical plant constructed by Western interests. We use several computer systems for process control and for monitoring and supervising some of the production equipment. As an electronics specialist, my responsibility includes support for some of these systems. Since the microcomputer boom arrived in Poland, we are also implementing this technology, primarily for applications in economic analysis.

Our enterprise currently has about 20 microcomputers compatible with IBM PC/XT and PC/AT models, but we are planning a much wider implementation of these machines. I find all aspects of microcomputer technology so interesting that I am withdrawing from the problems of large industrial computers to concentrate on small ones.

My involvement with micro systems is twofold: I select hardware configurations and maintain them in running order, and I provide both systems and applications software for creating multiuser, network, and communications systems. In addition, I try to use as many ready applications as I can. I also write my own programs. I am always striving to expand my knowledge; soon, I will take up postgraduate studies in the area of professional implementation of microcomputers.

In addition to my primary employment, I work with various microcomputer companies, delving into a variety of hardware and software problems. At present, I am working on implementing large data-processing systems based on powerful 32-bit microcomputers (for example, in the class of the IBM PS/2 Model 70-A21) networked under the control of a contemporary version of Unix, such as IBM's AIX or Interactive Systems' 386/iX. Smaller machines (such as IBM AT compatibles running under Xenix) would be connected to the main network with gateways or

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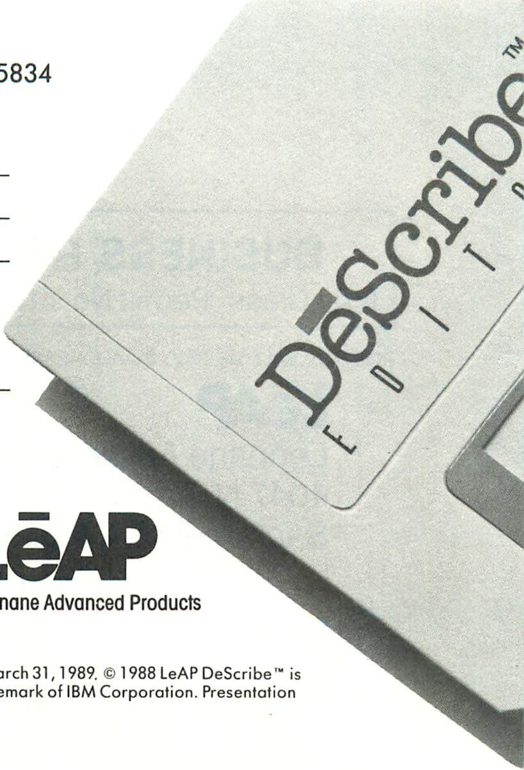

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with communications programs (such as UUCP) and high-speed modems (such as Telebit's Trail Blazer Plus).

The main problem I encounter is the limited access to current periodicals, books, and documentation from the West and, of course, limitations in availability of appropriate hardware and software. In that connection, I must say that your publication is a gold mine of valuable information on the newest microcomputer hardware and software. Because I cannot afford more than one subscription from the West (the current black-market exchange rate is 2,500 zloty to the dollar, and my salary and all other income total 60,000 per month), I had to make a well-considered selection of only one such periodical. After examining many publications whose copies manage sporadically to reach Poland, I chose *PC Tech Journal.*

Despite the many problems with obtaining the needed books and magazines, many people like me are quite involved in exploring the discipline of microcomputing. We seek out appropriate information in the various libraries associated with universities and technical institutions, and we maintain contacts with companies and institutions in the West, thereby keeping our knowledge of most developments in the field as current as possible.

Ryszard Grzegorski
Wloclawek, Poland

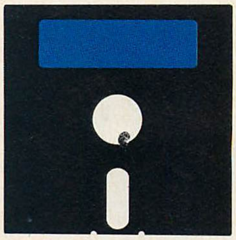
ERRATUM

In the November 1988 Tech Releases, the correct price for .RTLink from Pocket Soft Inc. (p. 44) should read $195. The product reduces the size on disk of all programs compiled under MS-DOS by as much as 92 percent. In addition, it supports fast linking and overlay management. *PC Tech Journal* regrets the error.

COMMENTS WELCOME

All letters to the editor should be directed to Editor, *PC Tech Journal*, Suite 800, 10480 Little Patuxent Parkway, Columbia, MD 21044. Correspondence also can be submitted over MCI Mail to PCTECH.

Although *PC Tech Journal* cannot publish all letters received, every effort is made to answer as many as possible. Please keep letters to the point, and include name, mailing address, and telephone number; when a letter is lengthy, a diskette is appreciated.



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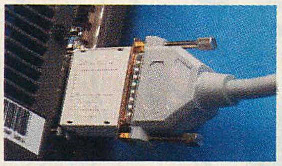
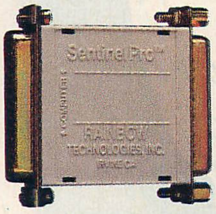
$3.0 billion in sales will be lost to free distribution — better known as software piracy. And right now, Rainbow Technologies' Software Sentinel™ is protecting close to $1.0 billion in software for developers who never wanted to be part of the free software distribution network in the first place. The Software Sentinel hardware key is "execution control" software protection. It ships with the software and simply plugs into the PC's parallel port to be one hundred percent invisible to both user and the software. Users can make as many copies as they want. Make working submasters. Use a hard disk. Virtually anything that can be done with unprotected software. Except start freely distributing that software to other users. The Rainbow family of Software Sentinel products. Selected by the very big to the not-so-big developers of DOS, OS/2 and Xenix software in worldwide markets. To the cool tune of close to a billion dollars. So far.





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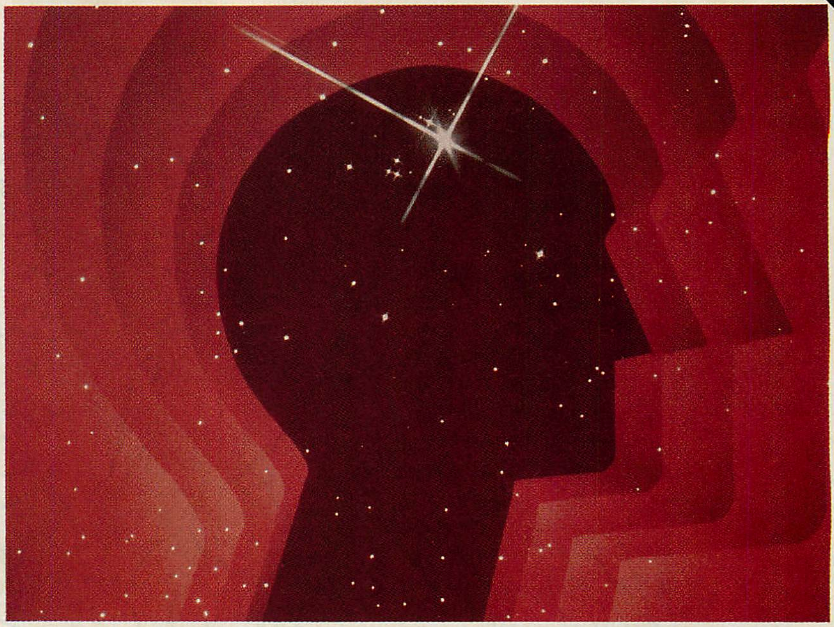

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NEW DIRECTIONS

Comdex Redux

The faithful stroll the crowded supermarket aisles of Comdex. □ *Also, printing standards and AST's FASTboard/386.*

Perhaps my growing weariness with Comdex is just the result of attending the event for the past eight years, or perhaps I have become jaded for other reasons. Regardless, the fall Las Vegas spectacular seems less spectacular with each passing year. It becomes harder and harder to find the phenomenal advances in hardware or the striking leaps of innovation in software that characterized the earlier years of Comdex.

Comdex/Fall '88 was more of the same—no startling revelations, no announcements to start your adrenaline flowing. Even so, there were some points of interest worth noting. They follow, by company.

IBM'S BARRAGE

Call this one the OS/2 and Micro Channel full-court press. IBM mounted an enormous effort in both areas. The IBM barrage consisted of two large booths on the main show floor as well as a press and dealer breakfast.

IBM's theme, "Right for today, ready for tomorrow," was designed to promote both OS/2 and the Micro Channel. At the press and dealer breakfast, IBM mounted a fantastic light show with lasers tracing the new slogan on a huge screen. Several IBM executives and business partners—Microsoft's Bill Gates, Enzo Torresi of Businessland, and Intel's David House—spoke to the assemblage.

The important messages of the morning were delivered by IBM's George Conrades (senior vice president and general manager of U.S. marketing), who said, "It's not OS/2 versus Unix; it's both," and William Lowe (Entry Systems president, since resigned), who strongly reaffirmed IBM's working relationship with Microsoft (at one point, Lowe even spoke directly to Gates in the audience). IBM is concerned that its recent activities in the Unix arena may be overshadowing its commitment to OS/2; IBM's messages were intended to assuage the press and give the dealers a greater sense of security.

IBM's booths were primarily showcases for OS/2 applications and Micro Channel solutions. About 300 Micro Channel boards from IBM and many third-party manufacturers were displayed, and IBM was distributing copies of its catalog of the 800 products already available for the Micro Channel. In my column last month, I reported that IBM had issued 1,300 Micro Channel adapter IDs to board manufacturers; at Comdex, IBM announced that the number had risen to 1,700.

Micro Channel technology was in the spotlight with performance demonstrations. The easiest to understand was a Micro Channel small computer systems interface (SCSI) adapter running seven hard disks simultaneously. Although the IBM SCSI board was a prototype, it showed not only Micro Channel performance, but also IBM's interest in SCSI.

Thus far, few products have been available to demonstrate the Micro Channel's value. Lantana Technology has introduced its Cypress/2 board, a 16-bit Token-Ring controller for the Micro Channel that can be configured as a bus master (see Tech Releases, this issue, p. 32). Lantana claims the bus master mode increases transfer rates and performance.

This brings to two the number of bus master products now available (the other is AOX's MICROMASTER 386 board for PS/2 Models 50 and 60). Two products hardly means the floodgates have opened, but it is a start.

MICROSOFT'S LAN PUSH

A lot of the OS/2 promotion from IBM naturally rubbed off on Microsoft, but the latter company had other Comdex missions; the most important one was the OS/2 LAN Manager.

Microsoft set aside a large room off the show floor to demonstrate the LAN Manager in operation. The hardware environment was a mixed bag (purposely, of course) that included a Token-Ring LAN bridged together with another Token-Ring network and a 3Com Ethernet LAN. All the machines used the LAN Manager, and most of the demonstrations involved accessing data across one of the bridges. The environment worked quite well and made for an impressive show.

Microsoft is pushing hard to make the LAN Manager the accepted LAN standard for OS/2. The effort it is putting forth is so large because the No-

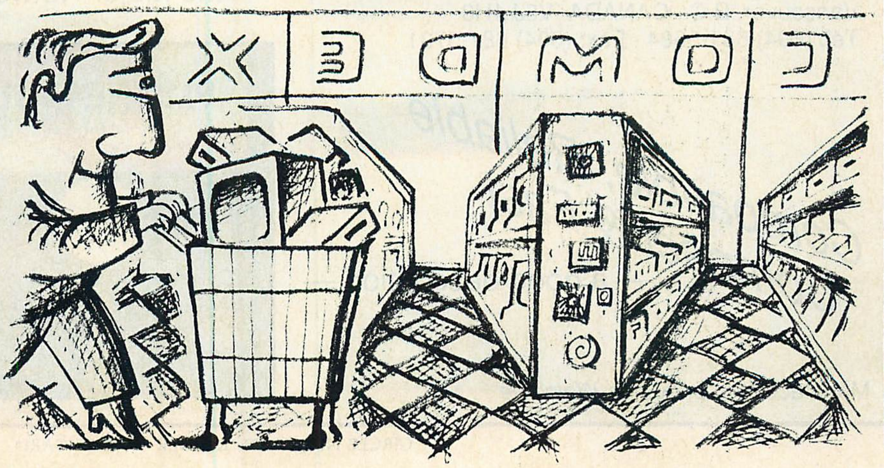

ILLUSTRATION • MACIEK ALBRECHT

vell standard is a tall, rugged mountain, and Microsoft has a tough climb. Its LAN exhibit at Comdex means Microsoft clearly realizes that.

AST'S TRANSFORMATION

In a special briefing for the press, AST Research announced several new computers and, in so doing, tried to put everyone at ease about the recent departure of cofounder Albert Wong, who will nevertheless remain on the board of directors.

The first announcement was an update to the Premium/386, designated the Premium/386C. The most significant change was the inclusion of a cache controller in the 20-MHz machine; the C family will replace the original Premium/386, which will be phased out. Pricing is aggressive, ranging from $4,395 for a unit with no hard disk to $9,795 for a unit with a 320MB hard disk. The Premium/386 was also displaced at the top of the line by the new 25-MHz Premium 386/25.

The 386/25 includes the Intel 82385 cache memory controller, as well as support for the 80387 and the Weitek 3167 coprocessors. Prices range from $6,595 with no hard disk to $11,795 for the 320MB model. The smallest hard-disk drive available is 90MB; this model retails for $8,995.

The most interesting announcement was a new workstation intended for use on LANs, but capable of operating as a small-footprint, stand-alone system. The Premium Workstation/386SX uses the Intel 80386SX, contains two AT-compatible slots, allows a choice of display options without using a slot, and can be configured with an optional internal hard disk. The price of the Workstation/386SX is $3,195 with no hard disk; $4,195 with a 40MB hard disk; and $5,195 with a 110MB hard disk. This is the first 386-based computer designed specifically as a network station, and it is sure to establish AST as a systems vendor.

AST is now better positioned to compete across the entire spectrum of price and performance. Starting at the low end with the Premium Workstation/286, AST has a system at every price and performance point on the graph. This relates to the rest of AST's presentation at Comdex, which centered on the stability of the company, its positive financial results, and its commitment to planning for long-term success, rather than responding to spot-market demands. The completion of AST's portfolio of systems reflects the completion of AST's transformation from an add-in board supplier to a full-fledged systems company.

INTEL PCEO GRAPHICS ENTRY

The Personal Computer Enhancement Operation (PCEO) of Intel announced a product in yet another enhancement category, graphics. The Visual Edge is designed to enhance the Hewlett-Packard LaserJet Series II by both increasing the printing speed of graphics and improving the appearance of printed images by using gray scales (see Tech Releases, this issue, p. 32). The $695 product consists of an add-in board for a classic-bus desktop computer, a cable, and an add-in board for the LaserJet. It is supported by a variety of software, including Aldus PageMaker, Xerox Ventura Publisher, all Digital Research GEM applications, and ZSoft's Paintbrush. Aldus provides the required Microsoft Windows driver for use with PageMaker; Microsoft's inclusion of the driver with Windows is uncertain.

The results are undeniable. Printing is two to six times faster, and the quality of images is immediately evident to the naked eye because of the increase in printed resolution. When used in conjunction with a video camera and a capture program such as Aldus's SnapShot, near-photographic quality images can be printed, significantly enhancing the output typical of desktop publishing.

Even if the software application does not support halftones, the Visual Edge still delivers its performance benefit. This is due to the use of the video I/O option port, a standard feature of the LaserJet II. The data-transfer rate through this port is higher than those for the parallel or serial port. The provided add-in board for the LaserJet II is installed in the "optional interface" slot on the rear of the printer.

For users of PC-based desktop publishing, the Visual Edge is a welcome product. Even if halftone support is not required, printing speed alone makes the product worth its price.

INTEL FOCUSES ON 486

With the pending announcement of its new 80486 processor, Intel was clearly concerned at Comdex that attention

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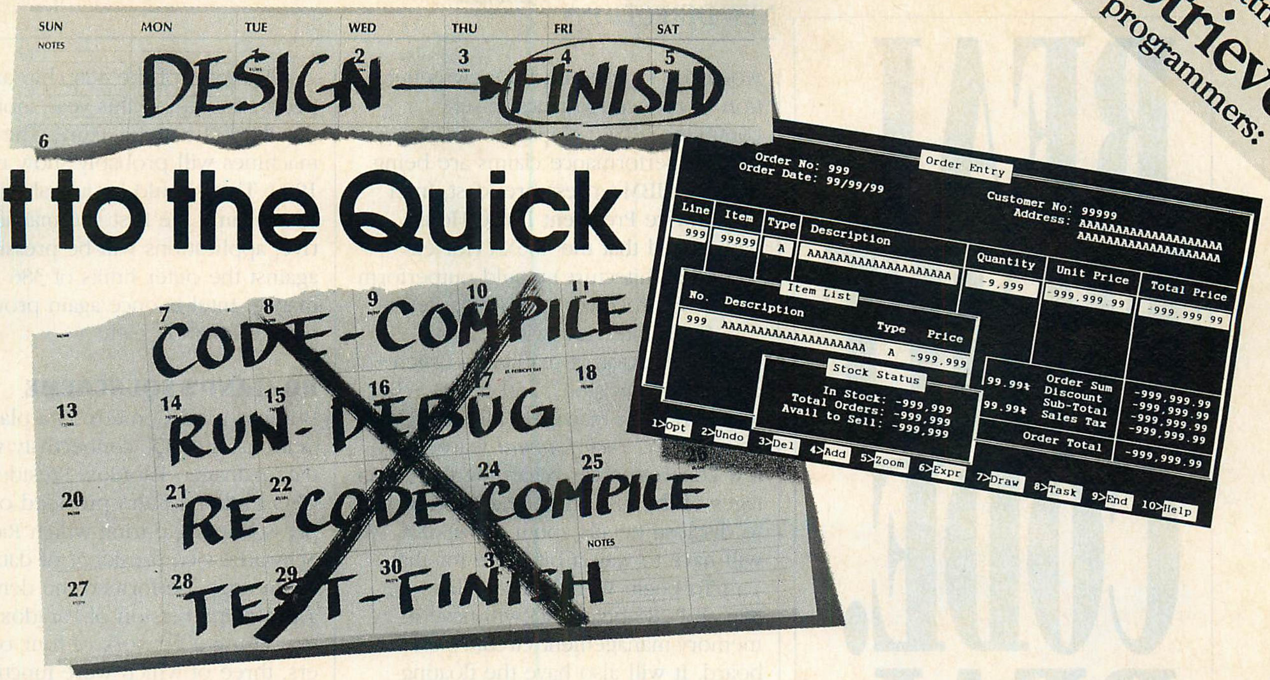

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would be focused on the new generation of reduced-instruction-set-computer (RISC) chips, for which significant performance claims are being made. At IBM's press breakfast, Intel Senior Vice President David House flatly stated that the 486XA (for extended architecture) would outperform any RISC processor on the market.

In an interview with Claude Leglise, director of marketing (Microcomputing Division), and Bruce Schecter, marketing manager (Mid-range Processors), *PC Tech Journal* learned a few concrete clues regarding the advantages of the 486 chip. (Intel is not ready to disclose details about the 486XA. We will have to wait a bit more for that.)

To begin with, the 486 (like the 386 and 286 before it) will have its memory-management circuitry onboard. It will also have the floating-point unit onboard, so there will not be an 80487. More than just an improvement in performance, the onboard floating-point unit will come with *every* 486-based system. I wish that were also true of the 386; perhaps we will see such an upgrade in the future.

Intel says that the best of RISC and complex instruction set computer (CISC) architectures will be combined in the 486. CISC is the instruction set upon which most of the world's desktop business software runs. The chief advantages of RISC, according to its advocates, are its speed and ease of design, which result because the majority of instructions take only one clock cycle. CISC architecture typically consumes several cycles for the equivalent RISC operation.

With the 486 processor, Intel is reducing to RISC levels the number of clock cycles required for many instructions. For example, a 386 register load (MOV memory to register) requires four clock cycles; a register load, two; and a register-to-register move, two. All three instructions will take only one cycle on the 486. The nine-cycle 386 CALL instruction will be reduced to three. Because the MOV and CALL instructions are the workhorses of the 80*x*86 family, dramatically improving their performance will have an equally dramatic effect on the performance of most software applications.

At the same time, the 486 instruction set will be binary compatible with the rest of the 80*x*86 family. It will still be a CISC architecture with all the benefits that complex instructions can bring, but with the added performance afforded by a reduced instruction set.

Samples of the 486 chip are expected sometime this year, along with details of the architecture. The first machines will probably show up in 1990. That should be just about right—by the time the first 486 machines arrive, applications will be pressing against the outer limits of 386 performance. Intel is once again providing a natural upgrade path.

BORLAND'S SQL SCHEME

Borland used Comdex as a platform to demonstrate SQL connectivity with its data manager, Paradox. President and CEO Philippe Kahn presided over a press briefing during which Richard Schwartz, vice president of database technology, performed the demo with a prototype version of Paradox.

Using a network of four computers, three of which were functioning as servers, Schwartz ran a PAL (Paradox applications language) program that queried each server, then constructed a local answer table based on information consolidated from all three servers. The PAL queries used standard Paradox query-by-example (QBE) forms; neither the user nor developer needs to have any SQL knowledge.

Borland's demonstration was effective; displays on each server showed the SQL queries being received and processed; then the answer table appeared at the workstation.

When the SQL feature is integrated into commercial versions of Paradox, it will be able to access IBM's Extended Edition Database Manager, the Microsoft/Ashton-Tate/Sybase SQL Server, the Oracle Server, and Novell's XQL server; Borland's demonstration included all but the Novell server. Network support will include the IBM OS/2 Communications Manager, Microsoft LAN Manager, 3+ Open LAN Manager, and Novell XQL. Integration of the SQL solution is scheduled for the second quarter of 1989; no price was announced for versions of Paradox with the SQL support.

Paradox will have two SQL releases. The first, in the spring of 1989, will provide connectivity to the servers mentioned. The second release (date not yet announced) will add at least one key feature: the ability to treat data on a server as if they were local.

In particular, this means using a multitable QBE form in which each individual form represents a single table—whether local or remote. In the first release of SQL connectivity, Paradox will be able to query only one remote table at a time, and then not

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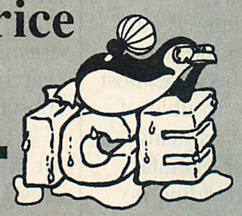

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How MagicCV works

MagicCV uses the 80386 to create a separate virtual machine for CodeView. MagicCV uses between 4K & 8K of conventional memory as a bridge between the DOS environment and CodeView.

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Both require 80386 AT compatible or IBM PS/2 Model 80. MagicCV requires at least 384K of extended memory. CodeView is a trademark of Microsoft Corporation.

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even in conjunction with local tables. It will be at least a year before the level of simplicity that Paradox has given us for local data becomes a built-in feature; until then, a multitable query will be cumbersome, and, although not *required,* PAL programming would improve efficiency.

Borland's SQL demo was impressive. A little whiff of vapor hangs in the air because the delivery date and price are so tentative, but to the best of *PC Tech Journal*'s knowledge, no other database front end yet supports more than one of the popular SQL-based servers, much less so neatly. If Borland can get the product out quickly, it will have scored a major coup.

RUTISHAUSER ADDS PAPER

One of the big problems associated with deploying a Hewlett-Packard LaserJet II printer on a network is the small capacity of its paper tray. At 200 pages, even light network printing can empty a tray quickly. HP offers a network printing solution in the LaserJet 2000 Model 2684P with its 2,000-sheet input bin, but it is expensive—$21,495.

Rutishauser is well known for paper-handling solutions for printers. For $895, its new TowerFeed 222 offers continuous feeding from two paper drawers, each with a 500-sheet capacity. Switching between drawers is automatic, and an empty drawer can be reloaded while paper feeds from the other drawer. The unit sits directly under a LaserJet II and is strictly mechanical; no electrical connections to the printer are required. The drawers can accommodate letter, legal, and European A4 paper sizes.

It is a simple, elegant solution.

SUNFLEX FILTERS

Sunflex offers a variety of anti-glare, anti-reflection, and static-control filters for display monitors. This is not exactly a new concept, but Sunflex's Voltfree series of filters can be mounted *behind* the bezel as opposed to the rather unaesthetic exterior mounting that typifies such products. Price ranges from $65 to $150, depending on the type of display and its size.

The effect is good. On the glaring Comdex floor, the Voltfree-equipped monitors were crisp and sharp.

PRINTING STANDARDS

I have often written about the problems created by the lively market for printers, a market that pushes manufacturers toward proprietary solutions that exploit the features of their particular products. We still lack an acceptable standard for applications to use when communicating with printers.

Sending a file to a printer is simple not because a common interface exists for all printers, but because most software vendors go to the trouble of building printer drivers for as many printers as they can. Printer manufacturers are notorious for providing no software drivers for their printers. The situation is so bad that two different programs printing to the same brand and model of printer can produce output with radically different appearances.

One solution to this problem is to devise a standard interface that all printer manufacturers would build into their printers, perhaps along the lines of Hewlett-Packard's printer control language (PCL), used in its LaserJet series. Unfortunately, this solves only part of the problem; millions of printers will still be out there without this standard printer interface built-in.

Furthermore, printer manufacturers are not likely to cooperate in this way; even if a new printer gives some token support to the Epson printer command set, for example, the manufacturer is usually adding proprietary capabilities to exploit the special features of its hardware.

A better solution is a common software interface. Adobe's PostScript language might be a good model, but it has the drawback of being large and the reputation of being slow, which is why most PostScript printers have their own, dedicated processor. PCL is leaner and might be a good application program interface (API), especially if it could be extended with a pass-through mode that would send non-PCL commands without interpretation. This would allow the more complex PostScript commands or other printer-specific information to be sent through the API with little or no overhead.

In a sense, environments such as Microsoft Windows and Digital Research's GEM operate in this manner. An application can write to a printer page, and the software driver does the best job it can to make it look the way the user expects. The same kind of behavior will be true of IBM's OS/2 Presentation Manager. The answer for any of these environments should be a properly constructed driver.

Still, this may not be enough. Even with Windows, GEM, and OS/2 demanding drivers, printer manufacturers do not ship diskettes with their equipment. This speaks eloquently for embedding a standard interface, or perhaps one of a half-dozen popular interfaces, directly in the printer hardware. Then, at least, the number of printer drivers that Microsoft or Digital Research would have to build would be substantially reduced.

The PCL driver that Aldus wrote for Windows, for example, supports not only Hewlett-Packard printers, but also some PCL-compatible printers. The minor differences between printers are smoothed out in the driver.

A systems developer has to deal with many problems when building an application. Wouldn't it be nice if figuring out how to support dozens of printers wasn't one of them?

AST FASTBOARD/386

I have always admired the AST Premium/286 for a variety of reasons (see the sidebar, "The Premium's Discount Premium," in New Directions, October 1987, p. 11). When the machine was announced in late 1986, it offered excellent performance at an excellent price; although the gap between it and its competitors has closed somewhat because of more recent products from other vendors, it remains an attractive 286 buy. One of its most attractive qualities is its 386 upgrade potential.

AST was the first vendor to expand the AT bus. When special boards are plugged into the Premium/286's two special FASTslots, the FASTslot connector takes precedence over the expansion bus, allowing 10-MHz, zero-wait-state operation of the memory. This results in performance equal to the typical 12-MHz system. The first add-in board to use the bus was AST's own FASTRAM memory board. (For a review of the Premium/286, see "Premium/286," Steven Armbrust and Ted Forgeron, June 1987, p. 74.)

When the machine was introduced, AST showed *PC Tech Journal* another option for the FASTslot, a 386 add-in board. The FASTboard/386 was eventually announced at Comdex in November 1987 and finally became available in the third quarter of this year.

The delay has been unfortunate because the FASTboard is an important reason to consider the Premium/286. The AST machine is the only 286-based system designed at the outset to provide a smooth upgrade path to a 386. As a result, FASTboard/386 may be the best 386 upgrade available.

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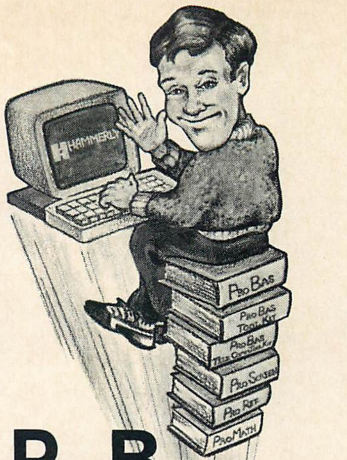

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TABLE 1: *FASTboard/386 Benchmark Comparison*

	AST FASTBOARD/386	AST PREMIUM/286	COMPAQ DESKPRO 386
EQUIPMENT			
ROM BIOS date	N/A	08/07/87	04/27/87
Processor speed (MHz)	16	10	16
Coprocessor speed (MHz)	16	8	16
Base memory size	4MB	640KB	1MB
Video controller	16-bit VGA	16-bit VGA	16-bit VGC
Hard-disk size (MB)	30	30	40
HLTEXT (text scrolling)			
BIOS	8.79	7.41 (84)[a]	4.34 (49)
DOS	17.14	17.08 (99)	5.71 (33)
C library	10.98	8.57 (78)	4.56 (41)
Windowed	6.48	5.32 (82)	2.47 (38)
Total	43.40	38.40 (88)	17.08 (39)
HLWINDOW (window/scrolling)			
Total	9.23	7.36 (79)	3.51 (38)
HLGRAPH (16-color graphics)			
400 small areas	4.28	6.26 (146)	3.84 (89)
100 large areas	3.02	3.79 (125)	2.63 (87)
400 small ellipses	4.06	10.32 (254)	4.56 (112)
200 large ellipses	3.79	9.67 (255)	4.23 (111)
4,000 short lines	3.35	6.42 (191)	3.46 (103)
2,000 long lines	3.13	5.76 (184)	3.13 (100)
General graphs	0.76	1.53 (200)	0.76 (100)
Total	22.41	43.79 (195)	22.63 (100)
HLSORT (CPU/Memory)			
Data generation	0.87	1.97 (225)	0.87 (100)
Memory sort	9.34	22.80 (244)	10.98 (117)
Total	10.21	24.78 (242)	11.86 (116)
HLFLOAT (Fast Fourier Transform)			
Forward	4.17	14.28 (342)	4.39 (105)
Reverse	4.23	13.90 (328)	4.45 (105)
Total	8.40	28.18 (335)	8.84 (105)
HLDISK (with disk cache)[b]			
Data file creation	3.62	3.24 (89)	3.18 (87)
Index file creation	24.01	46.75 (194)	20.32 (84)
First report generation	9.61	11.31 (117)	1.48 (15)
Data reorganization	13.40	15.65 (116)	3.73 (27)
Second report generation	3.29	3.40 (103)	1.09 (33)
Total	54.01	80.43 (148)	29.83 (55)

All times are in seconds, converted from 18.2-Hz timer ticks; therefore, total displayed is not always the exact sum of the individual results displayed.
[a] *Figures in parentheses represent relative performance expressed as a percentage compared with the AST FASTboard/386.*
[b] *The 256KB extended memory disk cache was implemented using vendor-supplied software.*

An AST Premium/286 with a FASTboard/386 installed performs as much as three times faster than a Premium/286 alone. Except in disk performance, a FASTboard-equipped Premium/286 rivals the 16-MHz Compaq Deskpro 386 in performance.

The basic FASTboard/386 comes with a 16-MHz 386 processor and 1MB of memory. It has a socket for the addition of an 80387 coprocessor; an adapter is provided to support less costly 8- and 10-MHz 80287 coprocessors. Access to RAM is speeded up with 64KB of 45-nanosecond (ns) static-cache memory. The FASTboard/386 lists for $1,995, or about $100 more than an equivalently configured Intel Inboard/386 for an AT.

An optional piggyback board for $1,995 comes with 4MB of 100-ns RAM. The board also includes sockets that allow another 4MB of RAM to be installed. The maximum memory configuration is thus 9MB, or three times larger than the one Intel's Inboard/386 currently supports. This large memory capability is extremely important for those wishing to use OS/2 or a 386 control program such as Microsoft Windows/386 or Quarterdeck's DESQview.

A member of the *PC Tech Journal* staff installed a FASTboard/386 in a Premium/286 and has been using it daily for several months. Installation is easier than for most add-in accelerator boards because you do not have to remove or resocket the 286 processor chip or install a cable. The FASTboard/386 simply slides into one of the two available FASTslots on the Premium/286.

The FASTboard software is necessary because an upgraded Premium/286 has both the original 286 processor and the added 386 processor running. Some I/O operations are handled by the 286, a benefit not offered by other 386 upgrade products. In addition, the software redirects ROM BIOS calls to its 32-bit memory, thus improving BIOS performance. Software also provides EMS (versions 3.2 and 4.0) and enhanced EMS emulations.

The *PC Tech Journal* system benchmarks show that the performance of an upgraded system is mixed, mostly because of the cooperative processing arrangement. In the key area of CPU-intensive operations, however, the FASTboard/386 turns in excellent results, yielding at least 2.5 times the performance of the Premium/286 itself (see table 1). Graphics performance improves by a factor of two with the FASTboard/386, and disk performance is about 50 percent faster—a good result considering that the hard-disk drive and its controller are not affected by the upgrade.

Text operation, on the other hand, slows down by 10 to 20 percent. This is a case in which the cooperative processing model breaks down; in effect, the system has to do more work to write text to the screen in comparison to a single-processor system.

PC Tech Journal's FASTboard/386 performs flawlessly. The machine in which it is installed is on a network and regularly runs a wide range of business and graphics software. The system's user has noticed and appreciated the dramatic increase in performance. Although the FASTboard/386 has been a long time coming, it has fulfilled the promises made by AST and turned the Premium/286 into an even more desirable choice among 286-based systems.

Will Fastie is the editorial director and founding editor of PC Tech Journal.

TECH RELEASES

The latest in hardware, software, and technology for systems developers and integrators.

GridCase 1535 EXP laptop

SYSTEMS

A small-footprint microcomputer using the 16-MHz Intel 80386SX has been announced by **Everex Systems**. Standard features of the **STEP386is** include 1MB of main memory (expandable to 4MB on the system board), six 16-bit and two 8-bit expansion slots, a 1.2MB 5.25-inch diskette drive, and a high-speed diskette/hard-disk controller that allows a 1:1 interleave and supports two hard-disk drives. A front-access panel includes an eight-character alphanumeric display that continuously updates system and drive status. $3,299.
Everex Systems Inc., 48431 Milmont Drive, Fremont, CA 94538; 800/356-4283
CIRCLE 304 ON READER SERVICE CARD

STEP386is PC from Everex Systems

NEC Home Electronics (U.S.A.) has unveiled three battery-powered laptops. The 4.4-pound **UltraLite** is driven by an NEC V-30 processor that runs at 9.83 MHz. Features include 640KB of RAM, an internal 2,400-bps modem, a 9.5-inch backlit blue-on-white screen that supports both text and graphics at a CGA-level resolution, a 1MB or 2MB silicon disk (9-ms access time), and a built-in battery with more than two hours of life. ROM cards augment the capacity of the silicon (non-volatile RAM) disk. An optional portable 1.44MB 3.5-inch diskette drive is available. 1MB, $2,999; 2MB, $3,699.

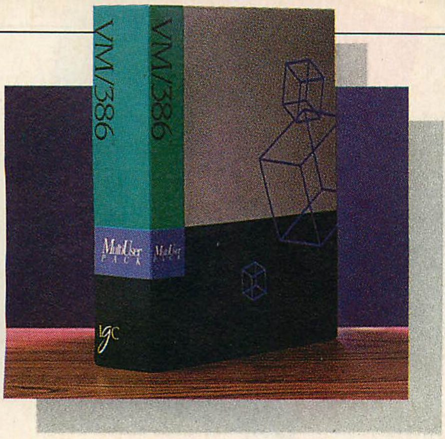
NEC also announced the release of the **ProSpeed 286**, a 14-pound, battery-powered laptop running at 16 MHz on an 80C286. The ProSpeed 286 is equipped with NEC's MonoGraph compensated twisted nematic (CTN) display and provides EGA resolution on a black-and-white screen; VGA capability is provided by an external monitor connector. Standard features include 1MB of RAM (expandable to 5MB); a 1.44MB or 720KB 3.5-inch diskette drive; three internal slots for a memory-expansion board, internal modem, and a general-purpose expansion chassis; and a 20MB, 40MB, or 100MB hard-disk drive. Prices start at $4,999.

A 16-MHz, 80386-based battery-operated laptop from NEC features modularity with its one-touch docking station concept. **ProSpeed 386** is detachable from its AC power source for travel and attaches for expansion and peripheral capabilities. It comes with 2MB of 32-bit 100-ns memory (expandable to 10MB in the portable unit and system maximum of 15MB). The NEC Expansion/3 system has three expansion slots: one for general-purpose use, another for expanded memory, and a third for a built-in, 2,400-bps modem. The display uses CTN technology, with cold-cathode, fluorescent-tube backlighting, and supports EGA and CGA for the LCD screen, with VGA support built in for external monitors. Prices start at $7,699.
NEC Home Electronics (U.S.A.) Inc., 1255 Michael Drive, Wood Dale, IL 60191; 800/632-7638; 312/860-9500
CIRCLE 302 ON READER SERVICE CARD

The 4-pound UltraLite laptop from NEC

A battery-powered, Intel 80386-based laptop has been introduced by **Grid Systems**. The **GridCase 1535 EXP** features a snap-on, snap-off tray that provides two 8/16-bit expansion slots for add-on boards. The 16-pound GridCase 1535 EXP operates at 12.5 MHz and includes a 40MB hard-disk drive, 1MB of RAM, and a 10-inch, 640-by-400 pixel, high-contrast backlit LCD screen. Options include a gas-plasma display, 2,400/1,200/300-bps internal modem, an 80387, and a maximum of 4MB of additional RAM. $7,495.
Grid Systems Corporation, 47211 Lakeview Blvd., Fremont, CA 94538; 800/222-4743; 415/656-4700
CIRCLE 303 ON READER SERVICE CARD

An 18.7-pound, 20-MHz 80386-based portable computer has been announced by **Toshiba America**. The **T5200** features a 640-by-480 pixel resolution, VGA-compatible, gas-plasma screen that supports 16 gray scales. The screen can be detached, allowing the T5200 to use an external VGA color monitor. The T5200, measuring 14.6 inches wide, 3.9 inches high, and 15.6 inches deep, can house one full-length, 16-bit expansion board and one half-length, 8- or 16-bit expansion board. Standard interfaces include a VGA color monitor port, two 9-pin RS-232C serial ports, and a port that can be used with a parallel printer or an external 5.25-inch diskette drive. Other standard features of the T5200 include 2MB of RAM (expandable to 8MB without using a slot), 32KB of high-speed SRAM cache with an 82385 cache controller, support



IGC's VM/386 MultiUser


3Com's 80286-based 3Station/2E workstation

for an 80387 math coprocessor, and a 1.44MB 3.5-inch diskette drive. MS-OS/2 will be available as an option. 40MB, $9,499; 100MB, $10,999.

Also announced by Toshiba is the 11.6-pound, 80C286-based, battery-powered **T1600**. The T1600 runs at 12 MHz with 1MB of RAM (expandable to 5MB). It has an on-board 20MB hard-


Toshiba's battery-powered T1600 portable computer

disk drive with a 27-ms access time and a built-in 1.44MB 3.5-inch diskette drive. The T1600 includes a detachable, backlit, supertwist EGA screen that features 80-character-by-25-line text and 640-by-400 pixel graphics and supports 16 gray scales. The laptop is designed with enough space to add a second removable battery pack. Batteries can be recharged in the unit or by using an optional three-pack external battery recharger. $4,999.
Toshiba America Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718; 800/457-7777; 714/583-3000
CIRCLE 301 ON READER SERVICE CARD

CONNECTIONS

VM/386 MultiUser, a system that allows one 80386-based system to act as a host for as many as eight PC-compatible terminals, has been unveiled by **IGC**. PCs and attached terminals running VM/386 MultiUser can be connected to a network and access the network data and applications without another file server or additional connections. The number of tasks that can run concurrently is determined by the amount of memory in the host computer and also the application's requirements. Data integrity is maintained through file-locking for multiuser applications.

Each user has a copy of DOS, AUTOEXEC.BAT, and CONFIG.SYS files and can have TSR programs. If an application crashes, the user can reboot the nodes without affecting the other active users or the host. Nodes may be up to 1,000 feet from the host with an in-line modem. Mice are supported on the graphics nodes. As much as 640KB of RAM, plus optional extended or expanded memory is offered. $895.
IGC, 4800 Great America Parkway, Santa Clara, CA 95054-1221; 800/458-9108; 408/986-8373
CIRCLE 313 ON READER SERVICE CARD

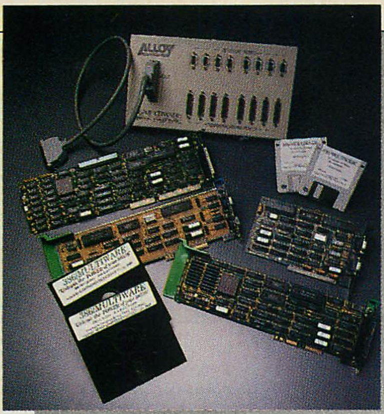
A 10-MHz, 80286-based LAN workstation, designed for use on a LAN that runs 3+ and 3+Open network operating systems, has been launched by **3Com**. The **3Station/2E** design features 16-color enhanced VGA in both standard mode (640-by-600 pixels) and high-resolution mode (800-by-600 pixels). It provides Systems Network Architecture (SNA), transport control protocol/internet protocol (TCP/IP), and asynchronous host connectivity with 3Com's Maxess SNA Gateway, PCS/TCP, and PCS/NS software products. Standard features include 1MB of RAM (expandable to 5MB), a built-in Ethernet connection, and a socket for an Intel 80287. With keyboard, $2,495.
3Com Corporation, 3165 Kifer Road, Santa Clara, CA 95052-8145; 800/638-3266; 408/562-6400
CIRCLE 311 ON READER SERVICE CARD

A group of backup systems designed for LANs and ranging in capacity from 400MB to 1.2GB is available from **Advanced Digital Information**. The **LANbacker** systems use an automatic changer device that controls a magazine of 10 DC 2000 cartridges with tape drives, ranging in capacity from 40MB to 120MB. The drive features 100-percent tape interchange, guaranteed by the use of a patented method that aligns the tape drive both mechanically and electrically to each cartridge. Prevention of unrecoverable data on tape is made possible by using 3M's patented X/OR error correction code and

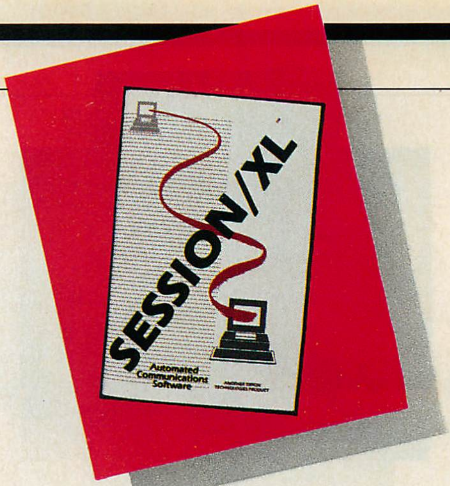

LANBacker 8000 backup system

the patented ferrite head that lasts 20 times longer than metal-head technology. The LANbacker systems use SCSI bus protocols, allowing as many as seven systems to be connected in parallel, providing for a total system capacity of 8.4GB. $7,995.
Advanced Digital Information Corporation, 14737 N.E. 87th Street, Redmond, WA 98052; 800/336-1233; 206/881-8004
CIRCLE 310 ON READER SERVICE CARD

The Personal Computer Enhancement Operation (PCEO) of **Intel** has announced its entry into the graphics marketplace with **Visual Edge**, an HP LaserJet Series II printing-enhancement system that consists of a PC half-card, printer adapter board, cable, and software. Visual Edge brings photographic-



Alloy's multiuser DOS-based 386/MultiWare



Triton's SESSION/XL

quality halftone reproductions to a range of applications and improves LaserJet II resolution by more than 300 percent and printing speed by between 200 and 600 percent.

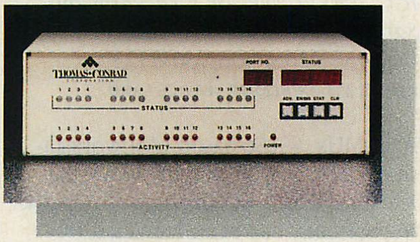
It is not a PostScript product; the Visual Edge system is based on a new Intel software programming specification—the image processing interface (IPI). This allows the system to accept gray-scale photographic image data from graphics applications and to turn them into halftones with a resolution of as many as 100 lines per inch, while maintaining complex levels of gray-scaling. Intel bundles the system with its EMS graphics manager, allowing users to employ their Above Board expanded memory as dynamic graphics printer memory. $695.
Intel Corporation, Personal Computer Enhancement Operation, Mail Stop C03-07, 5200 N.E. Elam Young Parkway, Hillsboro, OR 97124-6497; 800/538-3373
CIRCLE 305 ON READER SERVICE CARD

Alloy Computer Products has released a second-generation multiuser, DOS-based system. **386/MultiWare** runs both standard DOS applications and multiuser software and creates a multitasking environment, which enables each user to perform as many as eight tasks simultaneously. The 80386-based system enables a workgroup to share data and files, using terminals as their workstations.

Components of 386/MultiWare include NX386 operating system software and two intelligent multiport cards: the IMP2 and IMP8. The IMP2 provides ports for two users; the IMP8, connecting to an external terminal array panel (TAP), provides ports for eight terminals and an additional eight COM ports. Each IMP card has its own processor and RAM. The first product release supports a maximum of 21 users with two IMP2 and two IMP8 cards installed.

386/MultiWare will be available in the second quarter of 1989 in a variety of configurations—from a software-only, single-user multitasking capability to a 21-user system. $395 to $5,775 (386 PC and terminals not included). Three-user package, which includes two IBM 3151 terminals, $2,480.
Alloy Computer Products Inc., 100 Pennsylvania Avenue, Framingham, MA 01701; 800/451-8753; 617/875-6100
CIRCLE 312 ON READER SERVICE CARD

The family of intelligent ARCnet hubs from **Thomas-Conrad** is designed to provide ARCnet networks with on-line diagnostic capabilities. **Smart Hubs** feature the ability to enable or disable individual ports from the hub, a reading of the status of each port on the hub, and a count of reconfiguration attempts by port. Smart Hubs are available in a variety of configurations, including capacities of 8 to 64 ports, with terminations for twisted-pair, coaxial, and fiber-optic cable. Both 19-inch rack-mounted and stand-alone configurations are available for use in either 120 VAC/60-Hz or 240 VAC/50-Hz environments. 8-port unit, from $895.



Smart Hub from Thomas-Conrad

Thomas-Conrad Corporation, 8403 Cross Park Drive, Building One/C, Austin, TX 78754; 800/332-8683
CIRCLE 309 ON READER SERVICE CARD

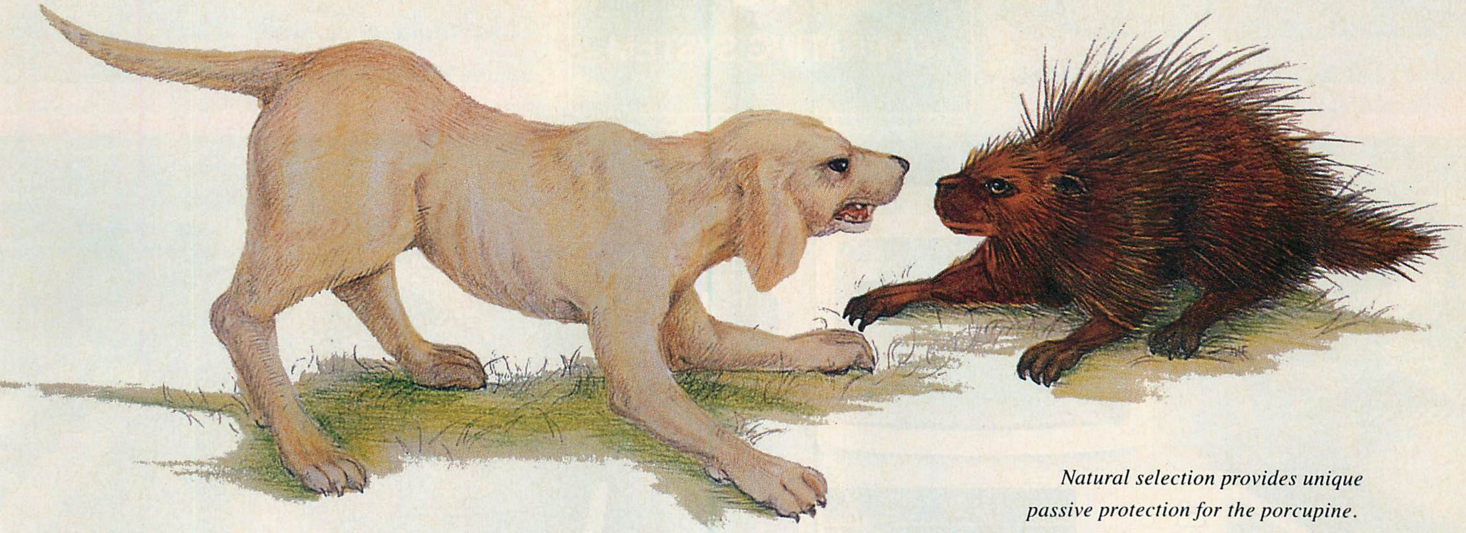
A powerful scripting and tasking communications language for automated file transfers, printing, and execution of programs and DOS commands is available from **Triton Technologies**. Features of **SESSION/XL** include support of conditional statements, sophisticated error checking, powerful command-line arguments, and variables for PC-to-PC communications tasks and operations. SESSION/XL's command-processing capabilities allow custom sessions to be created and automated between PCs. Transmission rates from 300 to 38,400 bps are supported. $225.
Triton Technologies Inc., 200 Middlesex Essex Turnpike, Iselin, NJ 08830; 201/855-9440
CIRCLE 307 ON READER SERVICE CARD

An enhanced version of **Corvus Systems**' distributed LAN operating system software for ARCnet, Ethernet, Token-Ring, NETBIOS, and Corvus's own Omninet has been released. **Version 2.0** of **PC/NOS** provides true distributed resource sharing, eliminating the need for a centralized file server and providing the capability to access all the resources on the network equally. Features include integrated asynchronous communications software, enhanced print spooling, and network-management capabilities. $695.
Corvus Systems Inc., 160 Great Oaks Blvd., San Jose, CA 95119-1347; 408/281-4100
CIRCLE 347 ON READER SERVICE CARD

A protocol-conversion device from **Modems Plus** allows IBM PC/XT and PC/AT compatibles to communicate with any compatible front-end processor in three modes. In 3770 Systems Network Architecture (SNA) and synchronous data link control (SDLC) batch mode, **MicroSNAP** provides 3776/3777 workstation emulation, printer emulation, concurrent DOS and 3770 sessions, and bidirectional file transfer.

In 2780/3780 bisynchronous communications (BSC), remote job entry

Software Developers



Natural selection provides unique passive protection for the porcupine.

The Activator - Natural Selection For Software Protection

Inventor and entrepreneur Dick Erett explains how "The Activator" provides sane protection for your intellectual property.

"In any industry, just as in nature, the process of natural selection raises one solution above another. Natural selection is the most elegant of engineers.

In the area of software protection The Block has been selected by the marketplace as the solution that works. Over 500,000 packages are protected by our device.

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A New Ethic For Software Protection

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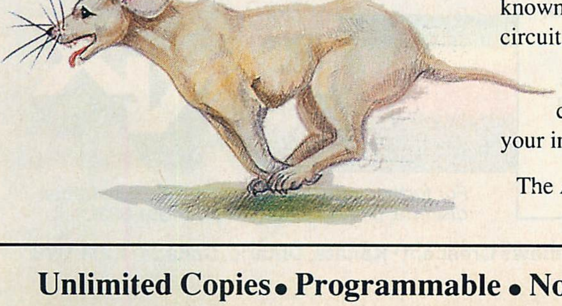

By removing protection from the magnetic media we remove the constraints that have plagued legitimate users.

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Our newest model, The Activator, builds on our current patented design, and establishes an unprecedented class of software protection.

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The Activator allows the software **developer** the option to program serial numbers, versions, or other pertinent data known only to the developer, into the circuit, and access it from the program.

Once you program your part of the chip, even we have no way to access your information.

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Just as no two snowflakes are the same, no two implementations of The Activator are identical. And like the snowflake the simplicity of The Activator is its greatest beauty.

We never cramp your programming style or ingenuity. Make it as simple or complicated as you desire.

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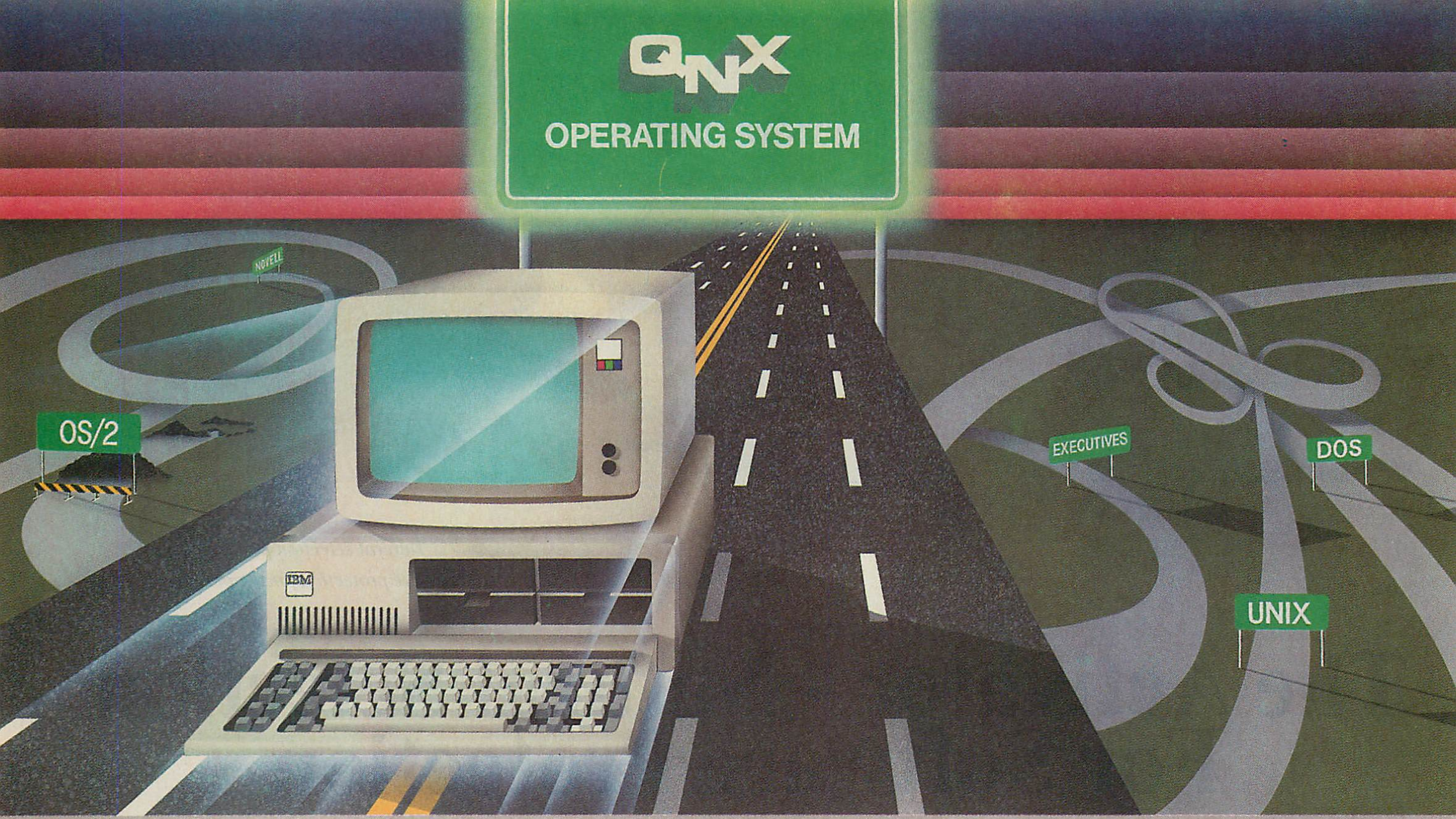

REAL TIME

Speed without compromise.

QNX® DELIVERS QNX delivers the speed of a dedicated real-time executive as well as multi-tasking, integrated networking and a multi-user development environment as rich and powerful as UNIX.

SPEED The tightly coded QNX kernel performs 3200 task switches/second on an AT, with full pre-emptive prioritized scheduling.

TASK COMMUNICATION QNX is based on a message-passing archi tecture, radically more innovative than PC-DOS, UNIX, or OS/2. User tasks and system tasks use the same messaging interface. This results in a single unified environment.

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RUNTIME ENVIRONMENT QNX architecture is modular not monolithic. The system consists of a set of tasks that provide services. Software developers can easily write tasks that add services to suit their specific application needs. It is straightforward to write tasks that interface to hardware through interrupts, I/O ports, DMA and dual-ported memory.

TECHNICAL SUPPORT Technical support is provided free of charge, and updates can be downloaded 24 hours/day from our online BBS.

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THE ONLY MULTI-USER, MULTI-TASKING, NETWORKING, REAL-TIME OPERATING SYSTEM FOR THE IBM PC, AT, PS/2, THE HP VECTRA, AND COMPATIBLES.

Multi-User	10 (32) serial terminals per PC (AT).	**C Compiler**	Standard Kernighan and Ritchie.
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Networking	2.5 Megabit token passing. 255 PC's and/or AT's per network. 10,000 tasks per network. Thousands of users per network.		
Real Time	3,200 task switches/sec (AT).	**PC-DOS**	PC-DOS runs as a QNX task.
Message Passing	Fast intertask communication between tasks on any machine.	**Cost**	From US $450. Runtime pricing available.

QNX

For further information or a free demonstration diskette, please telephone (613) 591-0931.

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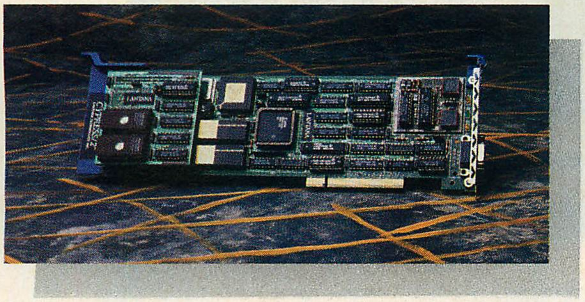


Cypress/2 Token-Ring board from Lantana

Digital's NetCommander 10G subLAN

(RJE) mode, it provides 2780 BSC emulation, printer emulation, concurrent DOS and BSC sessions, and bidirectional file transfer. In 3270 SNA/SDLC mode, it provides 3274 printer emulation and concurrent DOS, printer, and terminal sessions.

The MicroSNAP consists of a full-size board with 256KB of memory, a built-in microprocessor for handling the protocol-conversion tasks, and a menu-driven software program that allows emulation to be changed on the board rather than on the PC. With all three emulation modes, software, and hardware, $995; stand-alone version, $1,395. Quantity discounts are available with two or more units.
Modems Plus Inc., 3180A Presidential Drive, Atlanta, GA 30340; 404/458-2232
CIRCLE 308 ON READER SERVICE CARD

An array of IBM PS/2 Micro Channel network controllers from **Lantana Technology** has been introduced for major LAN topologies. The **Cypress/2** is a Token-Ring board that supports the bus arbitration capabilities of the Micro Channel and may be configured as a bus master controller. Cypress/2 offers three optional plug-in modules: a 128KB RAM piggyback board that incorporates a loadable IEEE 802.2 logical link control (LLC); an IEEE 802.5-compatible controller; and a 32KB EPROM module that incorporates LLC.

Also from Lantana, **Tamarix/2** is an Ethernet board that features a 10-Mbps transfer rate, a built-in internal transceiver, a BNC connector for thin (50-ohms) cable, and an external transceiver port for thick cable.

Aster/2 is an ARCnet board that features a 2.5-Mbps transfer rate, an on-board 2KB memory buffer, and a user-selectable node number. The Aster/2 board may be automatically configured via software, and features a 16KB EPROM socket for optional remote-program load (RPL). An active hub for splitting network cable and workstations over long distances in smaller networks and departmental cabling, as well as a passive hub for limited distances are available.
Cypress/2, $795; Tamarix/2, $549; Aster/2, $525.
Lantana Technology Inc. 4393 Viewridge Avenue, Suite A, San Diego, CA 92123; 619/565-6400
CIRCLE 346 ON READER SERVICE CARD

A sub-local area network (subLAN), announced by **Digital Products**, has a micro-mainframe gateway that allows IBM mainframe and PC users to share an asynchronous departmental printer. The **NetCommander 10G** emulates IBM 3287 and 3276 printers, enabling direct distributed access from IBM 3174, 3274, and 3276 mainframes to a departmental laser printer. This printer, while available to the mainframe, can also be shared by as many as nine PCs on the network. The NetCommander allows users to share files among PCs.

The product includes a 3287 SNA printer-protocol converter, which connects the subLAN to an IBM host via an IBM 3287 coaxial input port. The Type A coaxial port is compatible with all IBM 3174, 3274, and 3276 models and configurations. The NetCommander 10G subLAN has eight serial and two parallel ports. It supports both LU1 and LU3 operating modes. Menu-only access to the printer guarantees configuration security. Prices from $2,495 to $3,795, depending on buffer size.
Digital Products Inc., 108 Water Street, Watertown, MA 02172; 800/243-2333; 617/924-1680
CIRCLE 344 ON READER SERVICE CARD

An agreement has been reached between **INTERLAN** and **Grid Systems** to supply a custom IEEE 802.3 data-link controller for Grid's GridCase 1500 Series portable computers. The **Grid Ethernet Network Expansion Cartridge Model 34014** can be configured with either 8KB or 16KB of on-board RAM, with an access to a variety of network operating systems, such as 3Com 3+, Novell NetWare, Banyan VINES, PC NFS, and PC/TCP. Based on the Intel 82586 LAN controller, the Model 34014 cartridge features on-board diagnostics and packet buffering for both receive and transmit. The cartridge also contains an attachment unit interface (AUI) connection for external transceivers. $595.
INTERLAN Inc., 155 Swanson Road, Boxborough, MA 01719; 508/263-9929
CIRCLE 314 ON READER SERVICE CARD
Grid Systems Corporation, 47211 Lakeview Blvd., Fremont, CA 94538; 800/222-4743; 415/656-4700
CIRCLE 315 ON READER SERVICE CARD

An enhanced version of **RabbitSTATION Remote**, a connection to mainframes for the IBM PC, PS/2, and compatibles has been developed by **Rabbit Software**. **Release 4.0** of RabbitSTATION Remote enables a single workstation to access mainframe information via an IBM 37*x*5-compatible host front-end processor using the IBM Systems Network Architecture and synchronous data-link control (SNA/SDLC) and bisynchronous communications (BSC) protocols. RabbitSTATION Remote supports as many as eight host sessions, one DOS session, and one notepad session concurrently. Versions for two- and four-host sessions are also available.

Features include a configuration display utility; customer information control system (CICS) IND$FILE file-transfer support; a presentation space/application program interface (PS/API); High-level Language Application Program Interface (HLLAPI) 3.0 and a low-level interface; RabbitSCRIPT, a high-level, BASIC-like language interpreter; and native language support (NLS) for keyboards, character dis-

Mitsubishi's 20-inch Diamond Scan 20 L color monitor

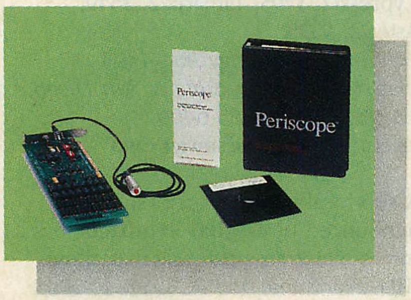
The Phaser LP and Phaser CP printers from Tektronix

plays, printers, and file transfer for non-English languages. The package includes software, an adapter board with processor, and 512KB of memory. Two-host session, $595; four-host, $795; eight-host, $1,395; upgrade, $50.
Rabbit Software Corporation, Great Valley Corporate Center, Seven Great Valley Parkway East, Malvern, PA 19355; 800/722-2482; 215/647-0440
CIRCLE 345 ON READER SERVICE CARD

A specially configured and packaged MicroVAX 2000 system designed as a server for PCs in a workgroup, department, or small business has been released by **Digital Equipment Corporation (DEC)**. The package includes the MicroVAX hardware platform; VMS 5.0 operating system; VAX/VMS Services for MS-DOS 2.1 integrated PC software; version 2.1, 16 DECnet/PCSA Client 2.0 software; licenses; PCMail; and broadcast utility software. Optimized for 8 to 30 PC users, **PCLAN/Server 2000 System** is simple to install, configure, and administer and is compatible with industry standards, such as OSI, DOS, NETBIOS, Microsoft Windows, and Ethernet 802.3. $18,800.
Digital Equipment Corporation, 146 Main Street, Maynard, MA 01754-2571; 800/344-4825
CIRCLE 306 ON READER SERVICE CARD

PERIPHERALS

An enhanced board for its Periscope I debugger has been added by **The Periscope Company**. The **Periscope I Revision 3** board enables programmers developing large applications to debug without using any memory in the lower 640KB of DOS. Its 512KB of write-protected RAM, which can be expanded to 1MB by the user, stores the Periscope software and all related debugging information, including symbols. The Periscope I has only a 32KB footprint in memory, which is addressed in the system above the lower 640KB (but in the first megabyte). For developers who need the hardware breakpoint and trace functions, the board can be used with Periscope III



Periscope I Revision 3 hardware debugger

(see "Hardware Assistance," Marty Franz, this issue, p. 58). It also can be used in systems with both and EGA or VGA and an expanded-memory board installed, which is not possible with the previous version. $695.
The Periscope Company Inc., 1197 Peachtree Street, Plaza Level, Atlanta, GA 30361; 404/875-8080
CIRCLE 316 ON READER SERVICE CARD

A 20-inch color monitor from the Computer Peripherals Division of **Mitsubishi Electronics America** is available. The **Diamond Scan 20 L** is a high-resolution, auto-tracking color monitor with microprocessor-controlled digital scan-mode memory. It supports low-end resolutions of 640-by-480 pixels to higher resolutions of 1,024-by-768 and 1,280-by-1,024 pixels.

A wide variety of analog graphics boards, including PS/2 VGA, Apple, RasterOps, Paradise, STB, Imagraph, and Number Nine, are supported. The digital scan-mode memory features a microprocessor in the monitor to automatically fine-tune the setting of display size and position (horizontally and vertically), for as many as 20 discrete combinations of settings. The monitor has a 100-MHz video bandwidth, with 30- to 64-KHz horizontal and 50- to 90-Hz vertical scanning frequencies, and a CRT dot pitch of .31mm. Diamond Scan 20 L, $3,650; 16-inch version, $1,945.
Mitsubishi Electronics America Inc., Computer Peripherals Division, 991 Knox Street, Torrance, CA 90502; 213/515-3993
CIRCLE 320 ON READER SERVICE CARD

The Phaser family of color and monochrome PC printers has been announced by **Tektronix**. The Phaser products include a 300 dots-per-inch thermal wax-transfer color printer, an 11-by-17-inch monochrome laser printer, and a multiple-emulation language controller board that resides in an IBM PC/XT, PC/AT, or compatible. The PostScript-compatible controller board supports both a color and monochrome printer, is software configurable, and includes 3MB of RAM (expandable to 11MB with the addition of a piggyback board).

The **Phaser CP** color printer system (including the Phaser controller board) produces letter-size and legal-size output on transparencies and paper, featuring 16.7 million colors. Printer speed is 45 seconds per copy, 30 seconds for monochrome. $13,000.

The **Phaser LP** laser printer system (including the Phaser controller board) produces five prints per minute in legal-size and eight prints per minute in letter-size at a 300 dots-per-inch resolution. $9,000.
Tektronix Inc., Wilsonville Industrial Park, P.O. Box 1000, Wilsonville, OR 97070; 800/255-5434
CIRCLE 317 ON READER SERVICE CARD

Enhancements to the popular **Hardcard 40**, a 40MB hard-disk drive on an add-in board, have been added by **Plus Development**. The Hardcard 40 now includes PlusCache disk-caching software (in order to achieve an effective

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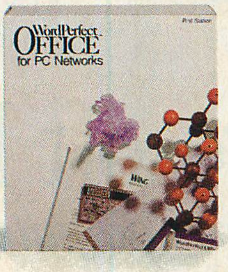

For more information write to WordPerfect Corp., 1555 North Technology Way, Orem, Utah, 84057
Or call (801) 225-5000. (In Canada, call 1-800-267-2499.)

WordPerfect
CORPORATION

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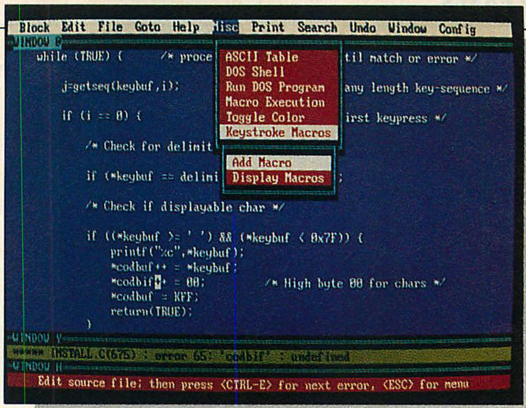
CIRCLE NO. 115 ON READER SERVICE CARD

QMS SmartWriter 150 laser printer



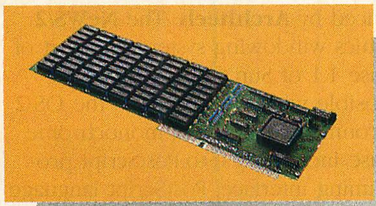
CompuView's VEDIT PLUS 3.0 with pull-down menus

access time of 28 ms) and a 16-bit frame (allowing it to fit in either an 8- or 16-bit expansion slot). Both the Hardcard 40 and the 20MB Hardcard 20 have an increased mean-time-between-failure rating of 60,000 hours and a two-year extended warranty. Hardcard 40, $995; Hardcard 20, $795. (Hardcard 20 owners may purchase the disk-caching software for $39.)
Plus Development Corporation, 1778 McCarthy Blvd., Milpitas, CA 95035-7421; 800/826-8022; 408/434-6900
CIRCLE 319 ON READER SERVICE CARD

The **SmartWriter 150** laser printer from **QMS** supports LN03, LN03 PLUS (which is the same as Tektronix 4014), and Hewlett-Packard LaserJet+ emulations. At the heart of the SmartWriter 150 laser printer is a QMS-designed internal controller, based on a Motorola 68000 CPU operating at 16 MHz with 2.5MB of RAM and 1MB of ROM. The ROM is used for the emulations and 19 resident fonts (additional DEC LN03 PLUS font cartridges are available from QMS). Based on the 15-page-per-minute Ricoh 4150 print engine, the SmartWriter 150 has a 15,000-page monthly duty cycle, dual 250-sheet paper bins, and 8.5-by-14-inch paper support. The printer can be attached to an Ethernet TCP/IP network via the QMS PrintLink controller. $6,995.
QMS Inc., One Magnum Pass, Mobile, AL 36618; 205/633-4300
CIRCLE 321 ON READER SERVICE CARD

IDEAssociates has introduced an 8MB, 32-bit Micro Channel memory-expansion board specifically designed for the IBM PS/2 Models 70 and 80. The **IDEAmax 80** features a dynamic-wait-state design, which allows it to operate on any Model 70 or 80 regardless of clock speed. IDEAmax 80 incorporates IDEAssociates' onboard memory checking and diagnostic scheme (OMCDS). This error-checking feature ensures maximum reliability by disabling the bank of modules where the failure occurs, while maintaining access to the remaining bank. The board offers as much as 8MB of memory using 1MB single in-line memory modules (SIMMs) and as much as 2MB using 256KB SIMMs. Both 256KB SIMMs and 1MB SIMMs may be mixed on the same board. IDEAmax 80 can use 80-, 85-, 100-, and 120-ns memory modules. IDEAmax is compatible with OS/2, EMS 4.0, and all software programs that have been developed for 80386 PS/2s. With 0KB, $495.
IDEAssociates Inc., 29 Dunham Road, Billerica, MA 01821; 508/663-6878
CIRCLE 318 ON READER SERVICE CARD

A memory-enhancement board has been added to **Boca Research's** BOCARAM family. **BOCARAM/AT PLUS** provides 80286 or 80386 system memory expansion for 16-bit, AT-bus computers. The board delivers backfilling capabili-



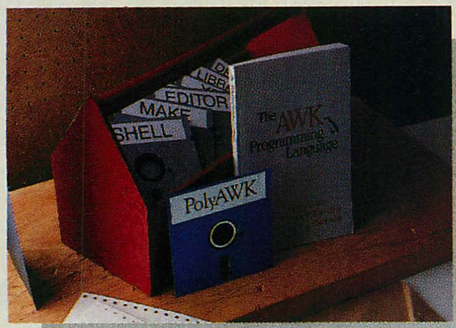
Boca Research's BOCARAM/AT PLUS board

ties and as much as 8MB of either hardware EMS 4.0 or extended memory. As much as 32MB of EMS 4.0 memory is possible with four BOCARAM/AT PLUS boards. BOCARAM/AT PLUS operates at speeds as high as 33 MHz. The BOCARAM/AT PLUS design accepts a variety of RAM chip speeds, such as 120-ns, 100-ns or 80-ns 1MB RAM chips through an installation program feature, which automatically matches the chip's access speed and the computer's bus speed. Boca includes a RAM-disk utility for high-speed disk emulation, a print-spooler utility, a comprehensive diagnostics package, free technical support, and a two-year warranty. With 0KB, $225; 2MB, $995; 4MB, $1,795; 8MB, $3,395.
Boca Research Inc. 6401 Congress Avenue, Boca Raton, FL 33487-2841; 407/997-6227
CIRCLE 348 ON READER SERVICE CARD

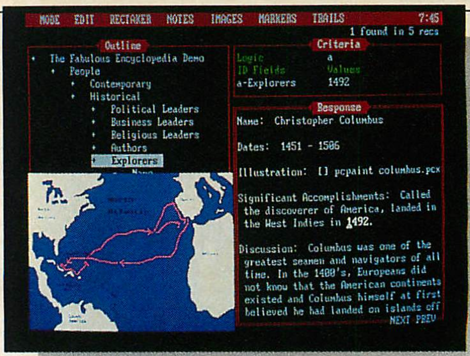
SOFTWARE DEVELOPMENT

For machines running DOS, Xenix, OS/2, FlexOS, and CP/M-86 operating systems, **CompuView Products** has announced an enhanced version of its **VEDIT PLUS** editor. **Version 3.0** includes pull-down menus, a multilevel Undo (1,000 levels), a full implementation of Unix-style regular expressions, columnar blocks, context-sensitive help, and a pop-up ASCII table. As with earlier versions, 3.0 has no limit on file size or number of lines and allows the editing of as many as 37 files at the same time, in any desired number of windows. Comprehensive pop-up status displays help the user manage as many as 36 scratch-pad buffers. The user can also execute DOS commands and other programs from within the editor. Fully definable keystroke assignments allow the user to customize the editor. $185.
CompuView Products Inc., 1955 Pauline Blvd., Suite 300, Ann Arbor, MI 48103; 313/996-1299
CIRCLE 326 ON READER SERVICE CARD

A computer-aided systems engineering (CASE) product that produces C source-code and executable programs directly from graphics specifications has been introduced by **SYSCORP International**. Using **MicroSTEP**'s mouse-driven, graphics specification environment, a developer interactively creates a system specification with sets of design tools designed to build data-flow diagrams, specify the data structures,



Polytron's PolyAWK toolbox



Crownshield Software's MediaBase data manager

lay out the screens, format the reports, and describe the application's computations and processing logic. Elements of a design specification can be copied and stored in the data dictionary for use in other specifications. $5,000.
SYSCORP International, 9420 Research Blvd., Suite 200, Austin, TX 78759; 800/727-7837; 512/338-0591
CIRCLE 323 ON READER SERVICE CARD

An OS/2 version of **Polytron**'s programming aid **PolyAWK** is shipping. A powerful pattern-matching language for writing short programs to perform common text-manipulation tasks, PolyAWK contains many features of the C programming language. Other features of PolyAWK include text substitution, definable functions, and built-in functions for strings, integers, and floating-point numbers. OS/2 version, $199; DOS version, $99; both versions, $249.
Polytron Corporation, 1700 N.W. 167th Place, Beaverton, OR 97006; 800/547-4000; 503/645-1150
CIRCLE 324 ON READER SERVICE CARD

An enhanced version of **Microsoft**'s **QuickBASIC** has begun shipping. **Version 4.5** includes QB Advisor, an online reference system that uses hypertext technology. Two other additions, QB Menus and QB Express, help first-time users become comfortable and productive in the QuickBASIC environment. Offering the same features as QuickBASIC 4.0, version 4.5 includes a smart syntax-checking editor, rapid compilation at speeds as fast as 150,000 lines per minute, and an improved source-level debugger with an instant-watch capability that displays the value of a variable or expression. $99; upgrade from version 4.0, $25; upgrade from earlier versions, $50.
Microsoft Corporation, 16011 N.E. 36th Way, Box 97017, Redmond, WA 98073-9717; 206/882-8080
CIRCLE 322 ON READER SERVICE CARD

A superset of ANSI C that supports the latest ANSI C extensions while preserving compatibility with existing C code is available from **Stepstone**. The **Objective-C Language 4.0** compiler features extensive syntactical and type checking to detect common programming errors. Type checking includes full ANSI C function prototyping, method prototyping for classes, and type-mismatch detection for all data-function combinations as well as for all objects with types that are declared by the programmer, even if the programmer is not using an ANSI-compatible C compiler. Other features include enhanced error handling, a message-tracing facility, and a wide range of binding options. $495.
The Stepstone Corporation, 75 Glen Road, Sandy Hook, CT 06482; 800/289-6253; 203/426-1875
CIRCLE 352 ON READER SERVICE CARD

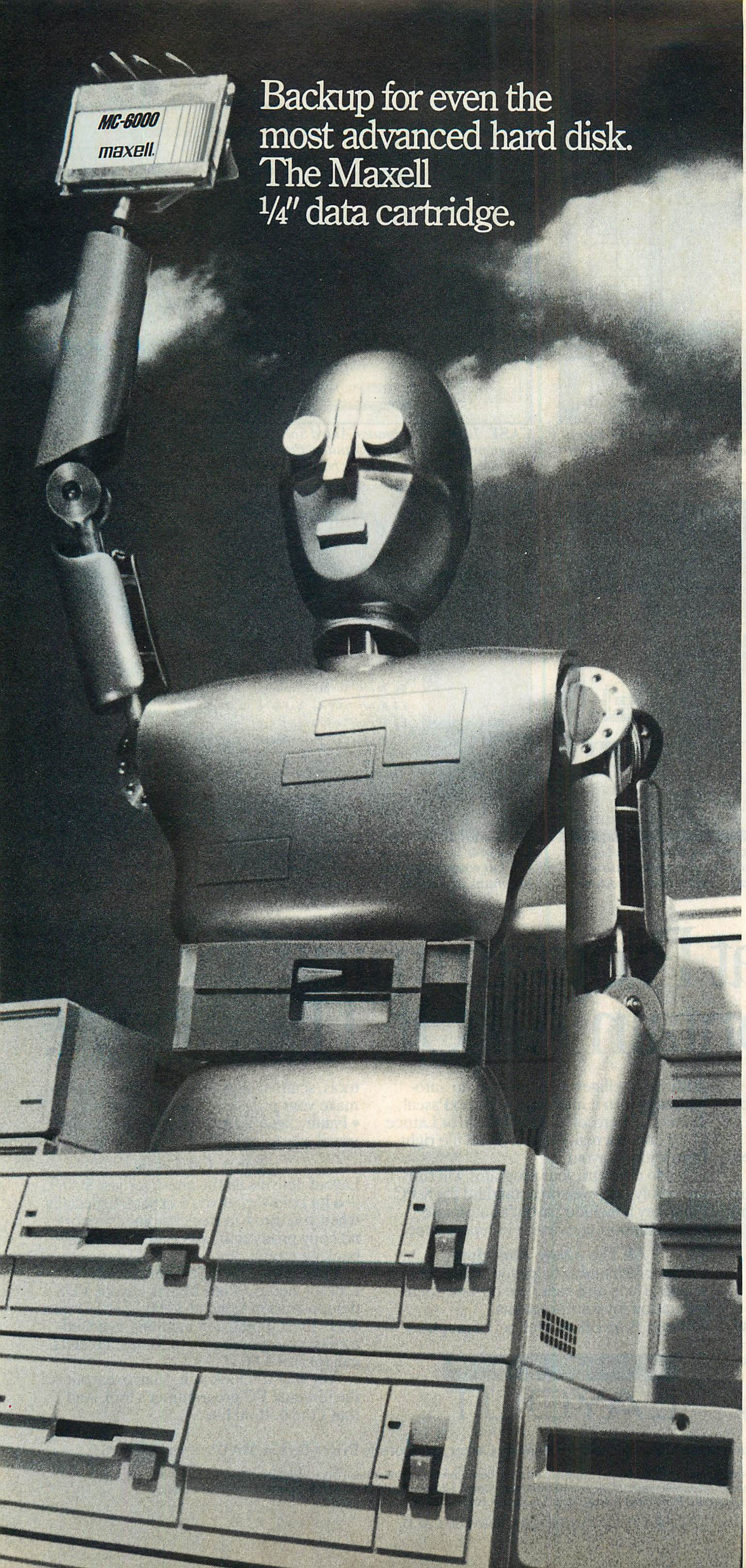
The release of a PostScript-based window system for OS/2 has been announced by **Architech**. The **NeWS/2** graphics windowing system is a port of release 1.1 of Sun's NeWS (network-extensible window system) to the OS/2 environment. The initial monochrome release includes a C-to-PostScript programming interface, PostScript language shell and previewer, calculator, spreadsheet, and journaling facility. In addition, NeWS/2 provides VIO-Term, a facility in which unmodified OS/2 character-based applications can execute in a NeWS/2 window. $400.
Architech Corporation, 850 Carroll Street, Brooklyn, NY 11215; 718/622-8577
CIRCLE 351 ON READER SERVICE CARD

A package from **Mortice Kern Systems** that offers programmers an automatic way of managing any size software project has been released. **MKS Make** automatically updates files and speeds up other tasks, such as documentation production, directory cleanup, software installation, and administration. AR, an object-code librarian program that has the look and feel of Unix AR, but is compatible with Microsoft LIB, is included with the package. MKS Make provides full compatibility with Unix System V AUGMake under DOS and user-definable meta-rules and dependencies, as in Sun OS Make. Support for linkers, libraries, revision-control systems, and a wide range of compilers is provided. $149.
Mortice Kern Systems Inc., 35 King Street N, Waterloo, Ontario, Canada N2J 2W9; 519/884-2251
CIRCLE 327 ON READER SERVICE CARD

DATABASE MANAGEMENT

A data manager that organizes, indexes, and retrieves data from multimedia information bases (including full-text data, graphics, video images, and audio and visual sequences) has been introduced by **Crownshield Software**. The PC-based **MediaBase** incorporates a user-defined, menu-driven data outliner that allows information managers to build and revise hierarchical information structures. MediaBase automatically indexes and reindexes data as they are entered or changed. A MediaBase record can contain unlimited text, graphics, audio, and video. $750.
Crownshield Software Inc., 1105 Commonwealth Avenue, Boston, MA 02215; 617/787-8830
CIRCLE 329 ON READER SERVICE CARD

A front-end productivity tool for **Progress Software**'s fourth-generation language (4GL) data manager has been introduced. A menu-driven application builder to be used with the Progress database manager, **PROGRESS FAST TRACK** consists of a screen painter, report writer, menu editor, and query-by-form generator. Using WYSIWYG techniques,



The loneliest feeling on earth is the feeling that comes right after losing the data you've worked so hard on for so long.

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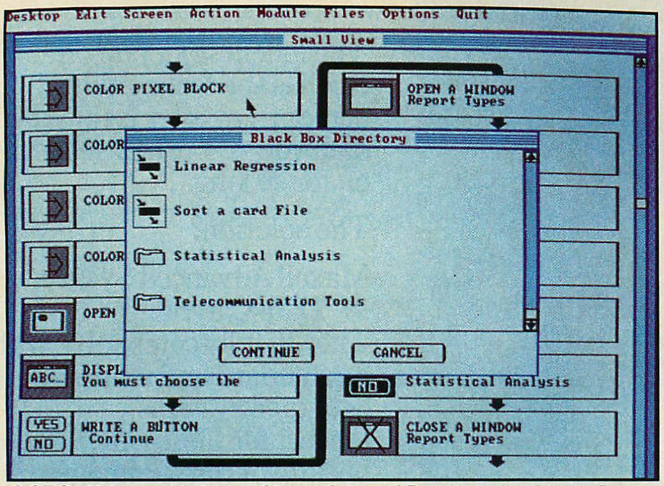

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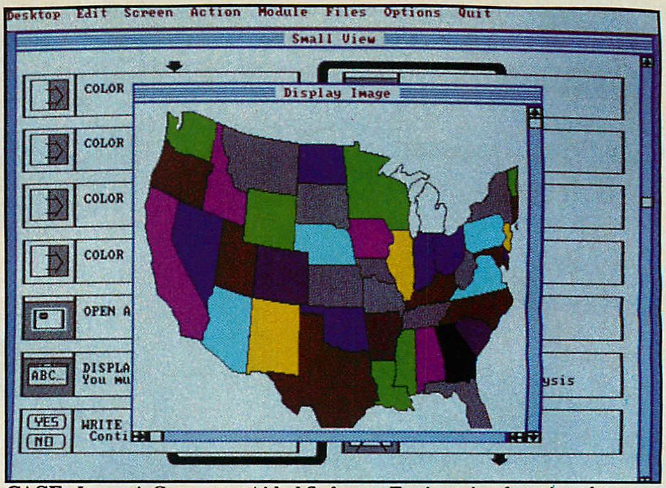
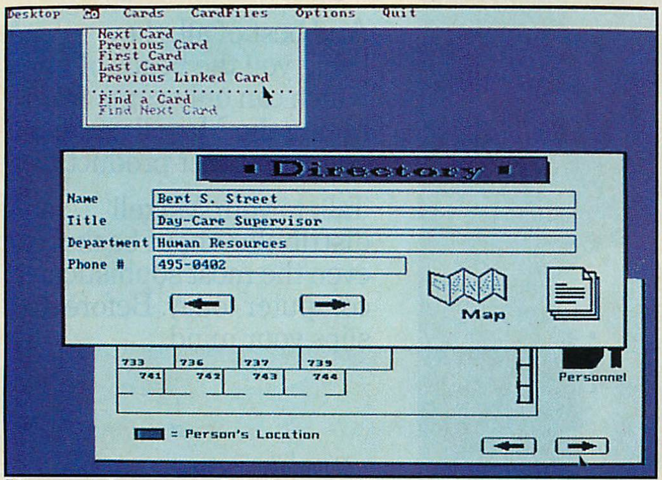
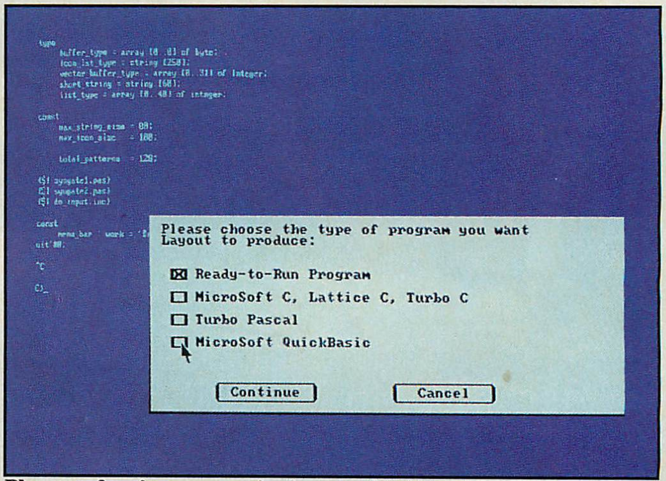


CASE. *Layout's Computer Aided Software Engineering functions let you design programs using an intuitive flowchart model. Then, Layout can automatically turn your flowchart into source code or even an .EXE file.*



Hypertext. *Layout puts all the features of Hypercard® on your PC and in your programs. Use Layout's graphical user interface to create documents with action links to related documents in any file. Or to create hyperlink applications.*



Plus, your favorite programming language(s). *Using Layout's tools, you can cut your coding time up to 70 percent, and still produce ready-to-run programs in your choice of languages.*

A Great Programming Tool Should Contain All Of The Above.

Presenting Matrix Layout, the first full software development system for the PC to promise you all the above. And deliver.

Sit down to Layout's intuitive user interface and in minutes you'll be using advanced OOPS (Object-Oriented Programming System) and CASE technology to build your program. Simply draw a flowchart indicating the windows, buttons, menus, text, and graphics you want.

A Cut Above Other Tools.

Layout also provides flowchart elements for Hypertext data base capabilities, math functions, variable management, conditional branching and looping. And, its open architecture allows you to build your own Black Box elements — to create exactly the program you want.

When your flowchart is ready, Layout uses artificial intelligence technology to automatically turn it into code — Turbo Pascal, Turbo C, Microsoft C, QuickBasic or Lattice C. Or create a ready-to-run .EXE file right from within Layout.

It's so efficient, your programs will run incredibly fast, even on a standard 256K PC. Plus, they'll include Layout's automatic mouse support and device independence.

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- *Matrix Helpmaker* helps you create context-sensitive help and complete on-line documentation for your programs.
- *Matrix Paint* offers a full set of graphics tools, scanner support, and clip-art files to make your programs look professional.
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MATRIX
LAYOUT

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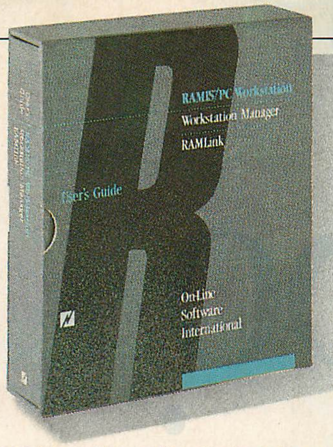
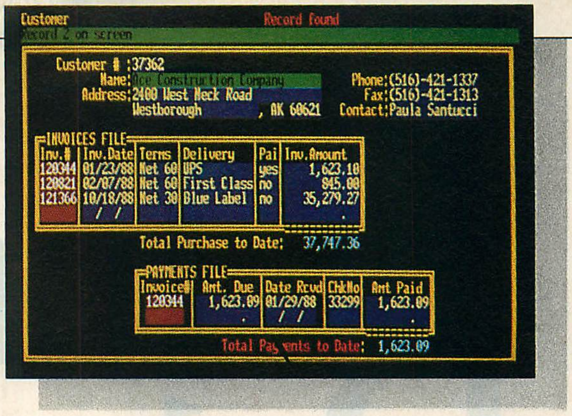


RAMIS/PC Workstation from On-Line Software



DataEase 4.0 data-entry screen

PROGRESS FAST TRACK allows developers to paint the desired result upon the screen by choosing fields from pop-up windows, and to define their applications through a combination of menu choices, commands, and point-and-click techniques. Price ranges from $1,450 to $154,000 (depending on the hardware platform used) for the PROGRESS Application Development System, which includes the PROGRESS 4GL data manager and PROGRESS FAST TRACK. PROGRESS FAST TRACK separately, $600 to $39,000.
Progress Software Corporation, 5 Oak Park, Bedford, MA 01730; 800/327-8445; 617/275-4500
CIRCLE 328 ON READER SERVICE CARD

A LAN version of **RAMIS/PC Workstation**, a multiuser data manager from **On-Line Software,** has been unveiled. RAMIS/PC Workstation features menu- and syntax-based reporting facilities, micro-mainframe connectivity, and a workstation software manager. Running under Banyan, Novell, and IBM PC LANs, RAMIS/PC Workstation features concurrent data access, comprehensive security, and automatic file- and record-locking. Existing RAMIS/PC applications do not require modification to run with the multiuser version. Enhancements to the database include improved data entry and maintenance, new command-file language features, and extended multiuser capabilities. 1 to 5 workstations, $2,000; 6 to 10 workstations, $4,000; 11 or more workstations, add $400 per workstation.
On-Line Software International Inc., Fort Lee Executive Park, Two Executive Drive, Fort Lee, NJ 07024; 800/642-0177; 201/592-0009
CIRCLE 330 ON READER SERVICE CARD

An applications-database generator is available from **Automated Software Concepts and Ideas, International** (ASCII). The **Turbo Programmer** consists of tools that allow a programmer to draw a database on a screen or a series of screens, use a point-and-shoot method to select the key fields, and generate a database. It has a main engine of C or Pascal source code that uses or references files created during the project's development stage. Hooks allow programmers to customize the engine to their particular needs. These hooks are situated before and after disk reads, disk writes, keyboard reads, and screen writes. The main engine never changes except for hooks the programmer adds, so all projects have the same programmer and user interface. $549.
Automated Software Concepts and Ideas, International, 3239 Mill Run, Raleigh, NC 27612-4135; 800/227-7681; 919/782-7703
CIRCLE 325 ON READER SERVICE CARD

Turbo Programmer from ASCII

A transaction-oriented relational database environment especially designed for LANs and wide area networks (WANs), is available from **VIA Information Systems**. Features of **VIA/DRE 1.2** include a full database server with peer-to-peer communications under OS/2 and DOS; a distributed data manager for transparent multinode joins between LANs with X.25; facilities for C and Structured Query Language (SQL), and an object-oriented language (VIA/COOL); an embedded, Level 1, ANSI-standard SQL facility with Level 2 extensions for use within either VIA/COOL or standard C programs; and advanced facilities for security and auditing. Automatic logging, checkpoint, restart, and recovery (forward and backward) are incorporated in VIA/DRE. VIA/DBA, a menu-driven data dictionary and VIA/PAINT, a utility for creating windows, pages, and fields interactively, have been added. VIA/DRE, $3,500; VIA/COOL, $1,395; both VIA/DRE and VIA/COOL, $4,500.
VIA Information Systems Corporation, 101 Carnegie Center, Suite 209, Princeton, NJ 08540; 609/243-0423
CIRCLE 349 ON READER SERVICE CARD

DataEase International has released an enhanced version of its data manager **DataEase**. **Version 4.0** features an enhanced DataEase Query Language (DQL) and offers 18 new DQL commands, including new programmable logic, global and local variables, I/O statements, custom error messages, and subroutines.

Enhanced LAN operations in 4.0 include increased performance rates (500 percent faster in some cases), automatic screen refresh for all users when a user modifies a file, and user-conflict messages that indicate which user is tying up an unavailable resource. Each file can hold as many as 2 billion records, and each application can contain a maximum of 2,000 procedures or reports. Single user (first LAN user copy), $700; Workstation Pack (adds three LAN users), $750. Upgrades: from 2.5 or LAN Server, $125; from prior versions, $175; from LAN Workstation Pack, $150.
DataEase International Inc., Seven Cambridge Drive, Trumbull, CT 06611; 800/243-5123; 203/374-8000
CIRCLE 350 ON READER SERVICE CARD

All material that appears in Tech Releases is based on vendor-supplied information. These products have not been reviewed by the PC Tech Journal *editorial staff.*

Turbo Debugging

Borland has added the missing ingredient to its product line with Turbo Debugger. It challenges Microsoft CodeView's preeminence among high-level language debuggers.

BEN MYERS

A generation of PC software developers cut their teeth on the venerable DOS DEBUG. Initially, it was the only debugging tool around, but the market soon exploded.

Today, a wide array of debuggers is available. The most significant recent development in the market is Borland's Turbo Debugger, which could attract users of not only Borland's languages, but also Microsoft's languages.

Since the early days of DEBUG, the debugger market has evolved into five broad, nonexclusive classes: assembly-language, symbolic, high-level language (into which Turbo Debugger falls), hardware-assisted, and in-circuit emulator (ICE) debuggers.

Assembly-language debuggers, of which DEBUG is the most famous and widely used example, work solely with machine code. Software developers writing in high-level languages cannot easily correlate source code with compiled assembly code. They must resort to tricks such as including program statements to write out values of critical variables during program execution.

With more complex applications, developers demand more sophisticated tools. Symbolic debuggers improve on assembly-level debuggers by using linker .MAP files or symbolic information embedded in the object-code file to relate assembly-level addresses to variables or functions. Disassembled code shows variable and function names, rather than hexadecimal operands. Microsoft's SYMDEB, introduced in 1985, is a symbolic debugger.

High-level language debuggers go one step further than symbolic debuggers by simultaneously displaying source and assembly code so that the logical relationship between them is readily apparent. The machine code is disassembled in clear relation to variables and functions, and developers can debug individual high-level language statements.

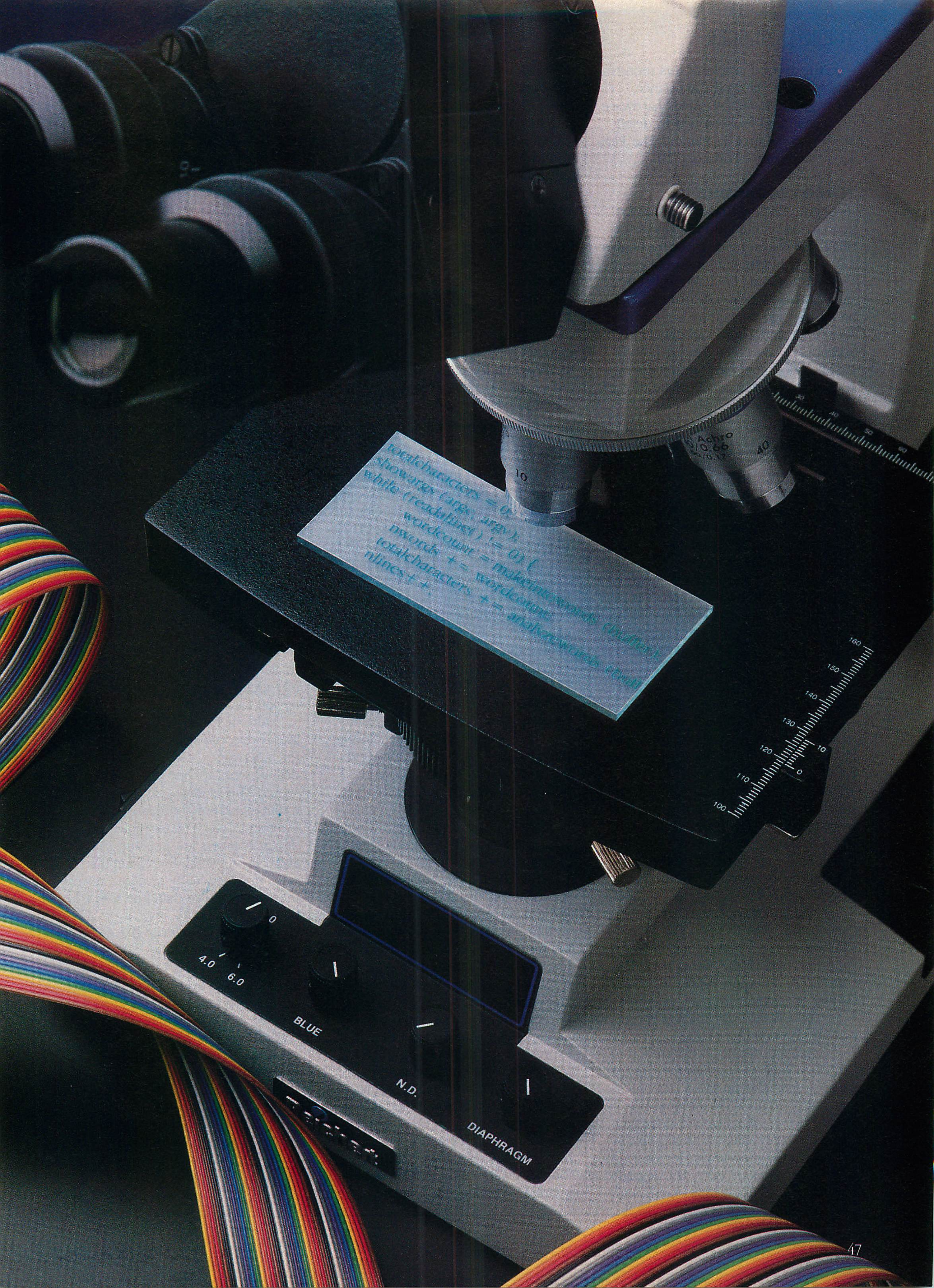
Microsoft's CodeView, introduced in late 1986, is the most popular high-level language debugger—and the one with which Turbo Debugger will compete most directly. Though primarily menu and window oriented, CodeView is downwardly compatible with the older command-line oriented debuggers, DEBUG and SYMDEB . (For a review of CodeView, see "Multilevel Debugger," Mark S. Ackerman, March 1987, p. 90.)

Rounding out the list are the hardware-assisted debuggers and the ICEs. These products are the most sophisticated and expensive PC debuggers.

Hardware-assisted debuggers typically control and monitor the debugging process with an expansion board installed on the bus. They are more flexible than their software counterparts because their hardware breakpoints do not affect the speed of a program; furthermore, they can run programs in protected memory, which can prevent the need to reboot when a piece of code hangs the system. Moreover, the software developer can usually break out of a feisty program with a break button. ICEs have the same features as hardware-assisted debuggers but are more expensive because they consist of outboard hardware that replaces the PC's processor.

MICROSCOPE COURTESY OF OPTICAL SYSTEMS DIVISION OF CAMBRIDGE INSTRUMENTS

PHOTOGRAPHY • BRUCE WELLER


totalcharacters = 0;
showargs (argc, argv);
while (readaline( ) != 0) {
wordcount = makeintowords (buffer);
nwords += wordcount;
totalcharacters += analyzewords (buff
nlines++;
BLUE
N.D.
DIAPHRAGM

The second article of this month's cover suite ("Hardware Assistance," Marty Franz, p. 58) examines hardware debuggers and looks at two in detail: Atron's 386 Source Probe and The Periscope Company's Periscope III.

TURBO ERGONOMICS

In August 1988, Borland International announced its high-level language debugging environment, Turbo Debugger 1.0, which began shipping in late September. Borland simultaneously introduced Turbo Pascal 5.0, Turbo C 2.0, and a package containing both Turbo Assembler and Turbo Debugger. In addition to other new features, both Pascal and C now have an integrated source-level debugger. Borland also offers two packages—Turbo Pascal Professional and Turbo C Professional—that bundle Turbo Assembler and Turbo Debugger with Turbo Pascal 5.0 and Turbo C 2.0, respectively.

Borland paid considerable attention to human factors when it designed Turbo Debugger's interface. The package is entirely menu driven—from the installation and customization programs to the debugger itself. By contrast, CodeView is a more cumbersome hybrid that uses both commands and pull-down menus.

Turbo Debugger has more than 200 hot keys and main- and local-menu commands. Despite this intimidating number, developers can easily navigate the program through the windows interface and its pop-up data-entry and selection boxes.

The main screen has a menu bar across the top to access primary functions, such as working with files, setting breakpoints, and running programs. The bottom line displays context-sensitive, function-key actions that vary for each window. When the user presses the Alt key, the bottom line shows additional options available using Alt with various key combinations. Pressing the Ctrl key shows the *local commands*, initiated by Ctrl combined with letter keys. Borland calls these commands local because they initiate actions in the current window.

Borland extends the window metaphor further with *panes*, which are logical subdivisions within a window. The tab key allows movement from pane to pane within any window. Progress

HELP FROM THE HARDWARE

All 80*x*86 processors have two features that help developers implement debuggers: the breakpoint instruction and single-step execution. The breakpoint instruction, INT 3, has a one-byte operand code (0CCH), not the two-byte form used by other interrupt instructions. Because an INT 3 is one byte long, it can replace the first byte of an instruction without corrupting subsequent ones (see Tech Notebook, this issue, p. 121).

When a program executes INT 3, the CPU transfers control to the breakpoint interrupt vector at low-memory location 0CH; the debugger will have previously set this vector to a debugger entry point. The CPU saves the code segment (CS) and the instruction pointer (IP) flag registers on the stack, with the IP pointing just past the INT 3 instruction.

To set an unconditional breakpoint, the debugger saves the breakpoint address and the byte of code at that address, then inserts an INT 3 there. When an INT 3 occurs, the debugger takes control and puts back the first byte of the instruction. Then, the user can issue commands to inspect or change program variables.

To resume execution at breakpoint, the debugger subtracts a value of one from the IP on the stack and does an IRET to execute the original instruction. The program runs under its own control until the next breakpoint occurs. Because the debugger executes only when a breakpoint is reached, the mechanism for unconditional breakpoints does not degrade program execution time significantly.

The second feature that aids tracing on Intel processors is single-step execution. The debugger enables this feature by setting the trap flag (TF) in the flags register. Whenever the TF is set, the processor transfers control to the address in the INT 1 vector (at location 4 in low memory) after executing each instruction. Single-step execution is slower than normal execution, often by a factor of 100.

Implementing conditional breakpoints using only these two features is laborious. If the user wants to break program execution based on the change of a variable in memory, the debugger must execute the program entirely in single-step mode. With each single-step interrupt, the program checks the variable being monitored for a change, and, if no change has occurred, executes the next instruction.

For conditional breakpoints set at source level, a well-designed debugger can run somewhat faster by inserting breakpoints at the first assembly instruction generated for each line of source code. A breakpoint-handling procedure tests the variable and continues program execution if no change is found. Conditional breakpoints based on the value of the expression are handled in much the same way. When a debugging interrupt occurs, the debugger evaluates the parsed expression to see if it is true and acts accordingly.

Additional debugging help comes from the 386 processor's ability to set four hardware-monitored breakpoint addresses. Debugging software can set a breakpoint for instruction execution, data writes, or data reads and writes; data breakpoints can be one, two, or four bytes wide.

Unlike the INT 3 instruction, 386 breakpoints do not modify the code to set an instruction breakpoint, and they can be set on data accesses. Breakpoint interrupts for this feature occur on the INT 1 vector; the single-step interrupt is still supported by the 386 on this vector, so the CPU provides a status register to give the reason for the interrupt.

Although the 386 debug registers are a welcome addition to the tools for a debugger, they still leave a great deal of work for the debugger designer. This is especially true in multitasking environments such as Unix and OS/2. For example, the debug registers are not stored in the task-state segment; therefore, the software must explicitly save and restore them when more than one task is being debugged.

A major element in the design of a 386 debugger is how to make best use of the four sets of debug registers. Watching data entirely with software is many times slower than with the 386 debug registers. Thus, the design of a 386 debugger favors watching data through the debug registers whenever possible. If the debugger allows more than four concurrent breakpoints, a combination of INT 3 and single-step interrupt handlers must suffice for the excess that cannot be accommodated by the 386 debug registers.

—Ben Myers

through windows already opened is even faster using *history lists*, which store the last sequence of choices made in the current session. As a short cut, pressing the Alt key and the window number selects an open window.

DEBUGGING ENVIRONMENTS

Unlike CodeView, Turbo Debugger has built-in support for a variety of hardware. It supports four different debugging environments: 8086 mode, 386 virtual mode, remote, and hardware-assisted debugging. In all modes, the Turbo Debugger user can step through statement execution, with or without dropping down into function calls, at both source-code and assembly levels.

To use the virtual-memory features when debugging on a 386, the user must install the TDH386.SYS driver in CONFIG.SYS and then run the 386 virtual debugger, TD386. TD386 runs entirely in extended memory, allowing the program being debugged (target program) to load and run at the virtual memory address it would use in actual conditions. The 386 device driver permits the developer to set hardware breakpoints for instruction fetches, memory reads, and read/write memory accesses at specified addresses (see the sidebar at left, "Help from the Hardware").

The target program can use 80286 and most 386 instructions, except for those that operate in protected mode. A toggle changes the display between the 32-bit 386 extended registers or 16-bit registers.

The virtual-8086 mode and memory management make the system practically immune to crashes, even if the target program destroys memory contents within its own address space. These same features, however, slow the program down and cause timing problems for some applications.

When a 386-based PC is not available or memory is at a premium, Turbo Debugger's remote debugging interface program, TDREMOTE, is a useful alternative. Turbo Debugger runs on the first machine, and TDREMOTE and the target program run on the second, effectively insulating the debugger from crashes. TDREMOTE requires only 15KB of memory, permitting the developer to debug large programs (see table 1 for a comparison of Turbo Debugger and CodeView target-program sizes). Setting up to debug a program in a remote PC is a relatively simple process. TDREMOTE and Turbo Debugger communicate through serial ports interconnected by a null modem cable.

TABLE 1: ***Turbo Debugger and CodeView Comparison***

	BORLAND	MICROSOFT
PRODUCT	Turbo Debugger	CodeView
VERSION	1.0	2.2
DEBUGGING PROGRAMS		
Compiled with /Zi (TDCONVRT)	●	●
With MAP files (TDMAP)	●	○
Supports other languages with .MAP files	●	○
OS/2	○	●[a]
Microsoft Windows	○	●
Turbo C 2.0 and Turbo Pascal 5.0	●	○
OTHER DEBUGGING FEATURES		
Views 32-bit 80386 registers	●	●
Uses 80386 hardware debugger features	●	○
Documented hardware debugger support	●	○[b]
Has remote debugging	●	○
Uses command macros or files	Macros[c]	Files
Logs output	●	●[d]
Views data structures in source format	●	○
Integrates use of mouse for commands	○	●
Uses expanded memory	●	●
Reports own and target's EMS usage	●	○
Searches for instructions in assembly code	●	○
MAXIMUM SIZE OF PROGRAM AND DOS (KB)		
8088, 8086, or 80286	411	410
80386	640	410
Remote PC	625	N/A

● = Yes ○ = No N/A = Not applicable

[a] CodeView for Windows applications is available with Windows 2.1 Software Development Kit.
[b] The CodeView file format is available to developers who enter into a contractual agreement with Microsoft.
[c] Command macros cannot be saved between debugging sessions.
[d] Screen output is redirected to a file and is not visible to the user.

Turbo Debugger offers users of Borland languages the functionality of Microsoft's CodeView, with many added features including Borland's use of the 386's memory-management and debugging features and innovative remote debugging.

TDRF, a program running the machine used for the debugger, supports file transfer between Turbo Debugger and the target PC. TDRF transfers data at 9,600, 40,000, or 115,000 bits per second (bps) and permits normal DOS functions such as file deletion and renaming, directory creation, deletion, and listing on the remote computer.

Borland provides documentation for writing device drivers for interfacing Turbo Debugger to hardware debuggers so that memory- and I/O-access breakpoints produced by the board are handled by Turbo Debugger. No vendors are yet shipping a compatible hardware driver, although several, including Atron and Periscope, are considering such a product. Borland says the interface eventually will support instruction trace-back and extra onboard memory for a symbol table.

If vendors of hardware debuggers provide their own drivers to meet the Borland debugger driver specification, the promise of well-integrated hardware and software debugging will be realized. Several hardware debugger manufacturers support CodeView format files under license agreements with Microsoft.

Turbo Debugger can use EMS 3.2 or 4.0 to store its symbol tables, and it keeps track of expanded memory used by the program being debugged. Expanded memory is used for symbol tables only; no executable code is loaded in EMS. On 386-based PCs, Turbo Debugger runs the target program in 1MB of virtual 8086 space (640KB of program space) and uses the 386 memory-protection hardware to keep the target program from contaminating the rest of the environment. Through 386 microprocessor capabilities, Borland has given the developer much of the functionality of a hardware-assisted debugger. CodeView users can get 386 functionality with MagicCV, an add-in product from Nu-Mega.

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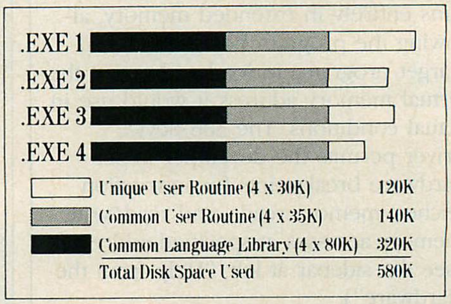
The code itself is not changed; only the linking process is changed – using today's most common link-input formats. These graphs illustrate the difference between a conventionally linked program and a program linked with .RTLink.

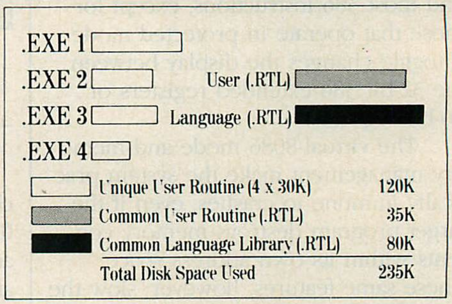
Now developers can realize the increased flexibility of designing programs using multiple .EXEs without suffering the penalty of increased disk space usage.

Disk Space Savings Example:

Program = 580K when conventionally linked.



Program = 235K when linked using .RTLink.



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While Turbo Debugger supports Borland's language compilers and assembler, developers also can debug programs written in Microsoft languages at the source level, using the TDCONVRT facility included with the debugger. The program converts Microsoft .EXE files compiled for CodeView into the Borland .EXE format.

Turbo Debugger works with most compilers and linkers that produce detailed .MAP files by using the included TDMAP utility to append Turbo Debugger information to the .EXE file. Turbo Debugger, however, operates only under DOS, not OS/2, and cannot debug programs compiled for the Microsoft Windows environment. Microsoft, on the other hand, has added OS/2-specific features to CodeView (see the sidebar, "CodeView Under OS/2: Nice Threads").

GETTING UNDERWAY

Installation of the three Turbo Debugger diskettes takes only a few minutes with the menu-driven INSTALL program, which automatically unpacks compressed files. The TDINST program controls several customization parameters; the user can change many while Turbo Debugger is running.

Customization options include choosing window colors; specifying editor, source, and debugger directories; enabling remote debugging and use of EMS; selecting the language syntax used for expression evaluation; and selecting how display video pages are managed between the debugger and the user screen.

TDINST has several options for handling screen swapping between the debugger and the executing program's (user) display screen image. If the system has multiple display pages, as in the CGA, EGA, or VGA, the Turbo Debugger screen will be maintained on a separate display page. The user can also swap screens in software—a slower, but less disruptive method.

A second monitor can display Turbo Debugger while the first displays the user screen. TDINST permits the user to update screens continuously, when a change occurs, or not at all.

The commands TD or TD386 followed by command-line options and the target program name starts Turbo Debugger. Commands follow either Unix style (preceded by a hyphen) or the DOS convention (preceded by a forward slash). An −h or −? displays all command-line options.

Source-level debugging requires programs compiled or assembled with the following options. For Borland's Turbo languages, the /v command-line option or its menu equivalent instructs the compiler to include debugging information in the .OBJ file. Microsoft languages that support CodeView require the /Zi option as if CodeView is the debugger. TDCONVRT then converts the resulting .EXE files. For properly linked and compiled programs, Turbo Debugger presents a source-code window, which displays the first executable lines of source code. Otherwise, the package displays disassembled machine language.

CODEVIEW UNDER OS/2: NICE THREADS

While Borland was busy creating Turbo Debugger, Microsoft was working to add OS/2-specific features to its existing CodeView debugger. In most respects, CodeView is unchanged since we last reviewed it (see "Multilevel Debugger," Mark Ackerman, March 1987, p. 90). However, Microsoft C 5.1 includes a major enhancement to CodeView that facilitates OS/2 debugging—support for multithreaded applications.

The OS/2 environment refines multitasking within a process to a *thread* level, OS/2's fundamental unit of scheduling. Unlike an individual process that has its own data space, an OS/2 thread shares the process environment of its parent. Starting a program under OS/2 actually invokes an instance of the program as thread 1. Thereafter, thread 1 can start other threads (for example, threads 2, 3, and so on).

The behavior of CodeView's standard commands is affected by these threads. For example, a breakpoint that is set with the BP command will stop when any thread reaches the breakpoint. Other commands, such as Trace, Step, and Execute, apply to the current thread, but also allow other threads to run concurrently. Thus, an Execute command will run the current thread in slow motion, but OS/2 can schedule other threads that could preempt that thread. Similarly, a Trace command will execute a single instruction in the current thread, but OS/2 may also run many instructions in other threads before it returns to CodeView.

To reflect the multiple-thread nature of OS/2, CodeView uses a command prompt that displays the number of the *current thread*, which is the thread currently selected for debugging (for example, 001>). Because every thread has its own stack and register set, the display changes to reflect new values any time the current thread is changed. Note that CodeView controls and monitors just the threads in the program being debugged; OS/2 schedules other threads in the system in the normal way.

For detecting elusive bugs in multithreaded programs, developers need precise control over threads. Help comes in the form of the thread command, ~ (the tilde character), to control execution of specific threads. The command has two fields. The first field specifies the thread to be operated upon:

n	thread number *n*;
#	the last thread executed;
*	all threads in the program;
.	the current thread.

The thread command's second field is a subset of the CodeView commands: BreakPoint, Execute, Go, Program Step, and Trace. Three other commands are also recognized. The Select command changes the current thread to the one specified. The Freeze command disables threads so they will not run in the background. Freezing all but the current thread, for example, ensures that only the thread being debugged runs during a specific section of code. The Unfreeze command reverses the effect of the Freeze uncommand.

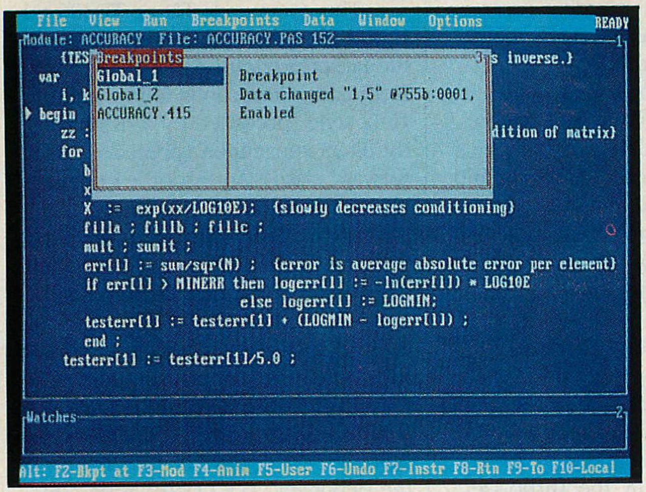
The thread command is powerful, but painfully cryptic. For example,

~	Show status of all threads
~*F	Freeze all threads
~3U	Unfreeze thread 3
~*G	Run all unfrozen threads
~2S	Make thread 2 current
~2BP .53	Set a breakpoint for thread 2 at line 53

CodeView has strong debugging abilities for OS/2, but they certainly look clumsy when compared with Borland's Turbo Debugger. If Microsoft intends for CodeView to reign supreme under OS/2, the company needs to send its debugger in for an overhaul before Borland hauls Turbo Debugger over to OS/2.

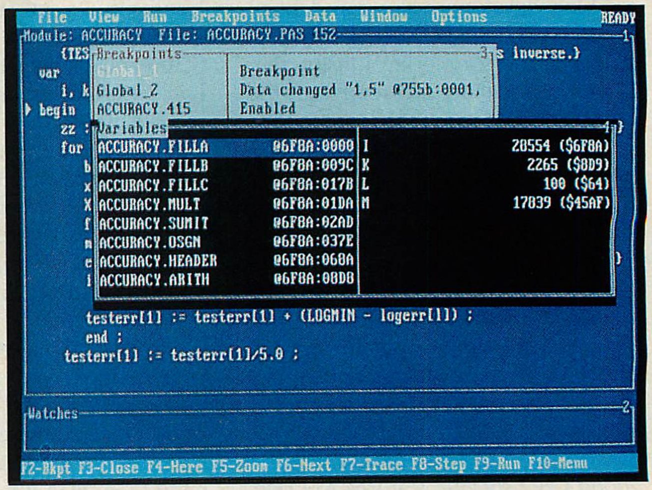
—David Methvin

PHOTO 1: *Setting Breakpoints*



A few keystrokes can set a breakpoint, run the program, trace the execution at the breakpoint, add another conditional breakpoint, and review current status in seconds.

PHOTO 2: *Viewing Variables*



A listing of all the variables in the program ACCURACY.PAS is only two keystrokes away—Alt-V, V. The right pane shows global variables; the left pane shows local variables.

Turbo Debugger has many options for running target programs. One possibility is to execute a single instruction, what Borland calls the *trace-into* function. This selection executes one instruction at a time, including calls. When traced, a call is executed and the window displays the code within the called function or procedure. Turbo Debugger also has a *step-over* function that executes the call and returns to the instruction following the call, treating the call as one logical instruction.

Another alternative is *animation*, which runs the program in slow motion, highlighting each instruction as it executes. Animation continues until the program encounters a breakpoint, terminates, or is interrupted by the Ctrl-Break keystroke combination. The user can set the time interval between animated instructions (0.3 of a second is the default).

Manipulating breakpoints is an easy proposition. The user sets breakpoints with either a single keystroke or from the breakpoint window (see photo 1). While the breakpoint window is active, the user can enable, disable, remove, and add breakpoints. To determine where to set a breakpoint, the user can examine local and global variables from the view-variables window (see photo 2).

Breakpoints can trigger when the target program reaches a specified line of source or assembly code, a variable has a stated value, or an expression is true. In Turbo Debugger, the term breakpoint encompasses the CodeView concepts of *breakpoint*, *watchpoint*, and *tracepoint*.

An *unconditional* breakpoint is a specific place in the program code where execution is to stop. A *conditional* breakpoint stops program execution only when a certain condition is true, such as when a variable has a given value or the program changes a value in memory. Turbo Debugger's conditional-breakpoint expressions are stated in the syntax of the source language (C, Pascal, or assembly) and can be conditioned on either an expression being true or a change in a variable.

A watchpoint evaluates a value of an expression and stops the program when the expression is true. A tracepoint checks all specified program variables or memory-referencing expressions for changes after each instruction executes.

The CPU window provides an all-in-one machine-level view of the target program. It has separate panes for disassembled instructions, registers, flags, stack values, and data. The user can also create multiple windows, each displaying a separate code or data area.

The dump window displays data in memory, as referenced by the current data-segment register of the target program. The user can search for and change a value in memory from the dump window. Data formats include byte, word, long, comp, float, real, double, and extended. In byte format, each byte is accompanied by its ASCII character representation. Turbo Debugger also displays data in any floating-point format supported by Borland compilers (including Turbo Pascal real) and any IEEE format supported by an Intel 80*x*87 math coprocessor.

The developer selects a source-code module (including the main module and any source files) for viewing and debugging through the module window. From this window, the developer can easily see the assembly code that corresponds to the source code by accessing the CPU window. This feature is a distinct advantage over CodeView, where the user has to scroll through assembly code to find the corresponding source code.

Turbo Debugger lists all variables in a program that have global scope, including function or procedure names, in the left-hand pane of the variables window. The right-hand pane displays all variables local to the current function or procedure. The window displays the current values of all variables in the format known by the source program. The value associated with a function name is a pointer, for example, and the value of a Turbo Pascal string variable is ASCII text surrounded by single quotes.

The package displays Turbo Pascal Boolean and enumerated data types with their source-code values as well as their integer equivalents; the values of Boolean variables are either true or false. Because the debugger displays data structures as aggregates of simple variables, the developer cannot change an entire data structure. However, elements of an array or data structure can be modified individually.

To see the status of and set and reset unconditional or conditional breakpoints, the developer accesses the breakpoint window. The F2 key is a quick way to toggle an unconditional

breakpoint anytime at a source- or assembly-code line where the cursor is positioned. The user can set conditional breakpoints based on either a change in a variable or an expression being true. Either makes the program run slowly because the debugger evaluates the breakpoint condition after single-stepping through each instruction and should be used sparingly, generally after stopping the program in a presumed problem area with an unconditional breakpoint.

The Turbo Debugger mechanism used for managing breakpoints is simple, is menu driven, and, unlike CodeView, does not use a command syntax for setting conditional breakpoints. The developer enters the expression that controls a conditional breakpoint into a pop-up window in the syntax of the language selected from the debugger option pull-down menu. Conditional breakpoints based on changes in variables also are entered into a pop-up window.

Turbo Debugger users can monitor simple variables or data structures in the watch window. The value of a watch variable is updated within the watch window while a program runs under control of the debugger. If the target program is running on a system with an 80*x*87 math coprocessor, the user can inspect, clear, and alter as many as eight 80-bit floating-point stack registers and 19 flags through the math coprocessor window.

The helpful user-screen function permits the user to see the actual screen the executing program would display at any given moment. Pressing Alt-F5 toggles between the user screen and the debugging screen.

LEARN FROM EXPERIENCE

Finding the bugs and examining the Turbo Pascal runtime library and DOS programs are easy tasks. For source-level debugging, the relationship between source and assembly code is readily apparent, particularly with the Turbo Debugger options to view either one or both. Turbo Debugger was installed on a PC Designs 8-MHz Turbo AT with an Atronics EGA+ video controller, a 16-MHz IBM PS/2 Model 80, and a Compaq 386/20. The package performed well when used to debug programs with several usual and some not-so-common problems.

Uninitialized variables. A source-code analyzer that executed correctly when compiled with Turbo Pascal 3.01 produced unexpected results with Turbo Pascal 5.0. Within 10 minutes, Turbo Debugger pinpointed an uninitialized variable that caused the problem. An unconditional breakpoint was set in a procedure where the problem was suspected, and the code was traced, watching the values of variables related to the symptom. The .COM file format of Turbo Pascal 3.01 had initialized the variable to zero, masking the logic error in the program. Without a debugger, a developer would have to analyze the source-code structure, which is less likely to pinpoint the problem and can be difficult and time-consuming.

Incorrect variable types. Julian date-translation procedures converted from Turbo Pascal 3.01 reals to 5.0 long integers failed when called by a production program, but worked when called by a test program. Turbo Debugger's two views of the variables revealed that the production program called the functions by passing integer variables rather than long-integer variables.

The Turbo Debugger mechanism for managing breakpoints is simple, menu driven, and does not use a command syntax.

Cooling hot spots. Turbo Debugger helped optimize the hot spot (a processor-intensive area) of a statistical analysis package. To view the generated assembly code, the .EXE program was loaded under control of Turbo Debugger; the source file for the procedure being optimized was selected. The cursor was then moved to the source lines being optimized, the CPU window was accessed, and the code generated by the compiler was inspected. As changes were made to optimize a major loop in the source code, the debugger displayed the corresponding assembly code. This comparison allowed examination of the clock cycles required for the generated code until a practical minimum was reached.

PC Tech Journal's OPTZTEST.PAS program, designed to test common code optimizations, was speeded up using Turbo Debugger to see what code Turbo Pascal generates (see photo 3). OPTZTEST (available for downloading on PCTECHline) uses the standard Turbo Pascal Move procedure to move information in memory quickly. The code in the Move procedure within the runtimes linked into the application was viewed. The Move procedure always does slower 8-bit moves (REP MOVSB) rather than fast 16-bit moves (REP MOVSW) for all but the odd byte being moved. A faster procedure was substituted for Move, resulting in a 50-percent reduction in processor time for moving data and a nominal increase in .EXE file size (see photo 4).

Dissecting FORMAT. The statistical analysis software mentioned above can monitor and count INT 13H disk BIOS calls; however, it failed to show disk activity for the DOS 3.3 FORMAT command when formatting a 3.5-inch diskette. Turbo Debugger verified that FORMAT does not use the INT 13H disk BIOS in this case. FORMAT was loaded under the control of Turbo Debugger, and unconditional breakpoints were set on INT 13H instructions.

On a 5.25-inch diskette, one breakpoint for each track was formatted with an INT 13H, AH = 05H (format track). When a 3.5-inch diskette was formatted, no INT 13H breakpoints were encountered. Turbo Debugger's Search function found the INT 13H instructions quickly; this could not be done with CodeView, because it cannot search for assembly-level instructions.

The arguments must be exact when the Turbo Debugger search function is used to find code in memory. A useful addition to Turbo Debugger would be the ability to search for occurrences of a symbolic operand (op) code, regardless of its hexadecimal value. This would make it easy to search FORMAT.COM for all OUT instructions, with any value from the set 0E6H, 0E7H, 0EEH, or 0EFH.

Bugs in the debugger. A minor malfunction occurred during testing. When TDH386 was run with the command-line arguments FORMAT B:, FORMAT did not find the B: argument, indicating that the 386 version of the debugger may not be setting up the program segment prefix of the target program correctly. The non-386 Turbo Debugger performed correctly under the same conditions. Borland technical support said the problem will be corrected, but would not commit to a definite date.

SUPPORTING PLAYERS

Several utilities play important supporting roles for Turbo Debugger. After debugging is complete, the TDSTRIP utility removes symbol-table information from .EXE files, which eliminates the need to recompile a program to get a finished product.

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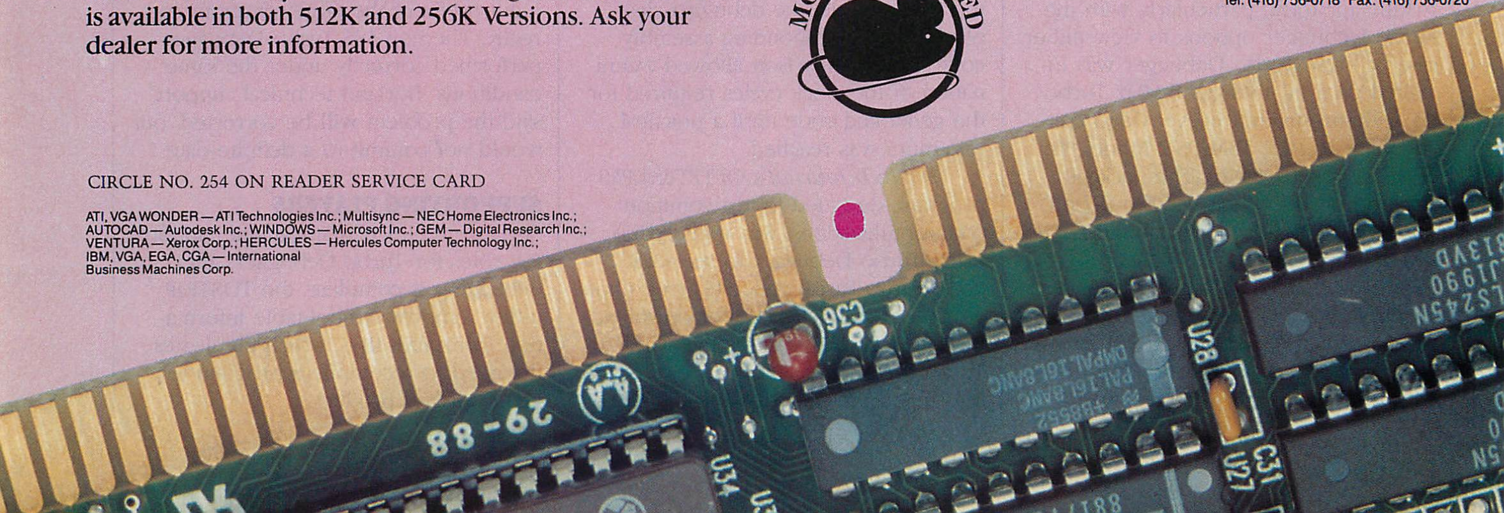
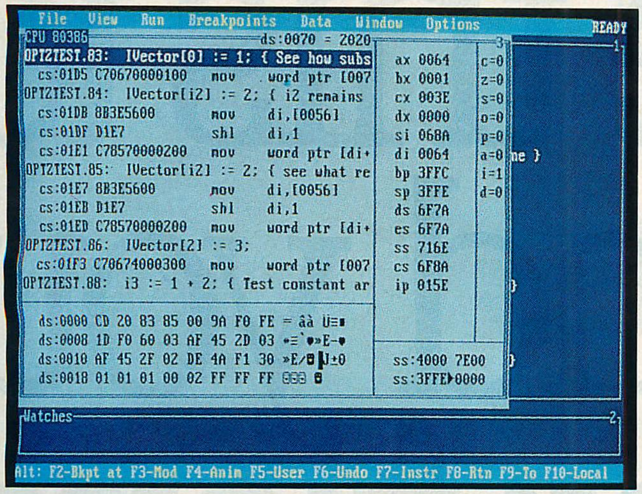
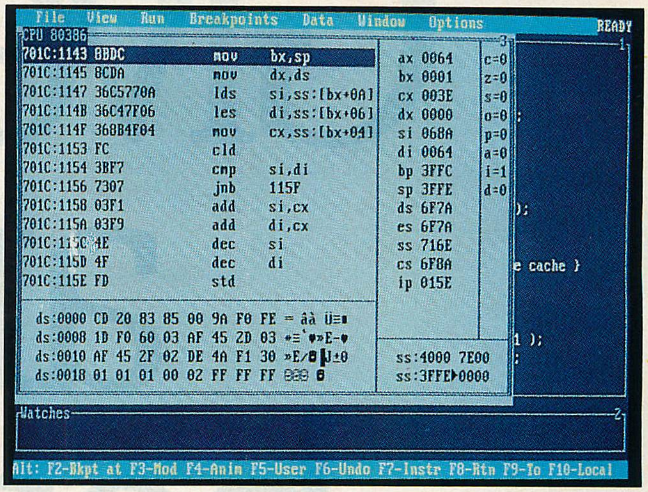


PHOTO 3: *CPU Status*



Disassembled machine code generated by Turbo Pascal overlays the related source code in the CPU window, whose five panes include stack, registers, flags, code, and a data pane of raw data in the area of memory selected.

PHOTO 4: *Assembly Code Implementation*



Another view of the CPU window shows the underlying assembly-code implementation of a Move procedure call in Turbo Pascal. This kind of analysis by Turbo Debugger can help in making decisions optimizing performance.

If a program that was compiled with a non-Borland compiler is linked with .MAP files, the TDMAP program appends the .MAP information to the .EXE file in Turbo format. The user can then debug these programs with Turbo Debugger. With TDMAP, developers also can use Turbo Debugger on Turbo Pascal 4.0 programs. The steps to do this are as follows:

- Compile Turbo Pascal 4.0 program with /$T+ command-line option to create a .TPM file.
- Create a .MAP file from the .TPM file using the Turbo Pascal 4.0 utility, TDMAP.
- Run TDMAP to combine the .EXE file with information from the .MAP file into Turbo Debugger format.

Another worthwhile utility, TDUMP (which Borland calls a module disassembler), is actually a file analyzer that breaks down the structures of programs, object files, and libraries. TDUMP does not disassemble code, but relies on the debugger to do so. For programs, TDUMP decodes the .EXE file header and shows the initial stack segment address, the program entry point, and all addresses requiring loader relocation.

For object files, TDUMP formats the segment definition information, PUBLIC symbols, and locations requiring linker fix-ups. The utility also displays the contents of all data and code segments in hexadecimal format. For libraries, which are collections of object files, TDUMP shows the same .OBJ information and some library-specific information.

If a file is not in one of these three formats, TDUMP simply prints a file dump in hexadecimal, ASCII, or both. It does not analyze the structure of Turbo Pascal 5.0 .TPU or .TPL files, which are the equivalent of libraries in other languages. No Turbo Debugger utility is provided to accomplish this task, but TDUMP does give a straight hexadecimal readout of the files.

The TDPACK utility reduces the size of the debugging information appended to the executable code of an .EXE file. For example, a 55KB file compiled with debugging information grew to 115KB. TDPACK eliminated about 9,000 bytes of duplicate information, such as strings and data-type information. If Turbo Debugger runs out of memory while debugging a large program, running TDPACK could help. All the utilities display a list of options when started without a command-line argument.

The *Turbo Debugger User's Guide* is well written and detailed, covering installation and overall operation. The bulk of the guide explains operation details, such as examining and modifying files and data, setting breakpoints, and evaluating breakpoint and watch expressions in the target program's source language. Several chapters explain the nuances of debugging programs at the assembly level and debugging with an 80x87 coprocessor.

AN EXCELLENT VALUE

Finding bugs in software is a complex task. While no software can replace careful analysis, high-level language debuggers provide an invaluable aid. With Turbo Debugger, the developer can work in the familiar high-level source-code environment, but can easily drop down to compiler-generated machine instructions.

Turbo Debugger is a solid addition to any software developer's toolbox and rounds out Borland's programming product line. It has many attractive features including an easy-to-use interface; close integration with Turbo C and Turbo Pascal; the ability to debug CodeView-compatible .EXE files; and the capacity to debug very large programs, either on a 386-based PC or remotely, using two PCs.

Moreover, the package is a bargain. Borland sells Turbo Assembler and Turbo Debugger bundled together for $149.95. Turbo Debugger is included with Borland's Professional Turbo C and Professional Turbo Pascal; both packages sell for $250.00 each. Current users of Turbo C or Turbo Pascal can upgrade to the Professional packages for $99.95 each.

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Turbo Debugger 1.0
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Ben Myers, owner of Spirit of Performance Inc. in Harvard, Massachusetts, specializes in languages and other software. His last article for PC Tech Journal *was a review of Turbo Pascal 4.0 in April 1988.*

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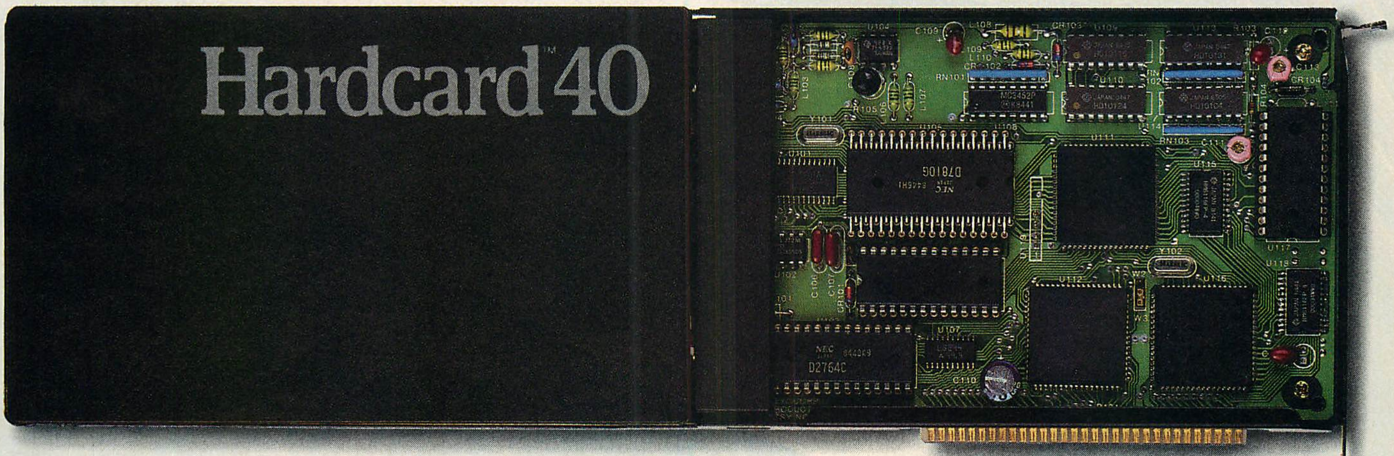

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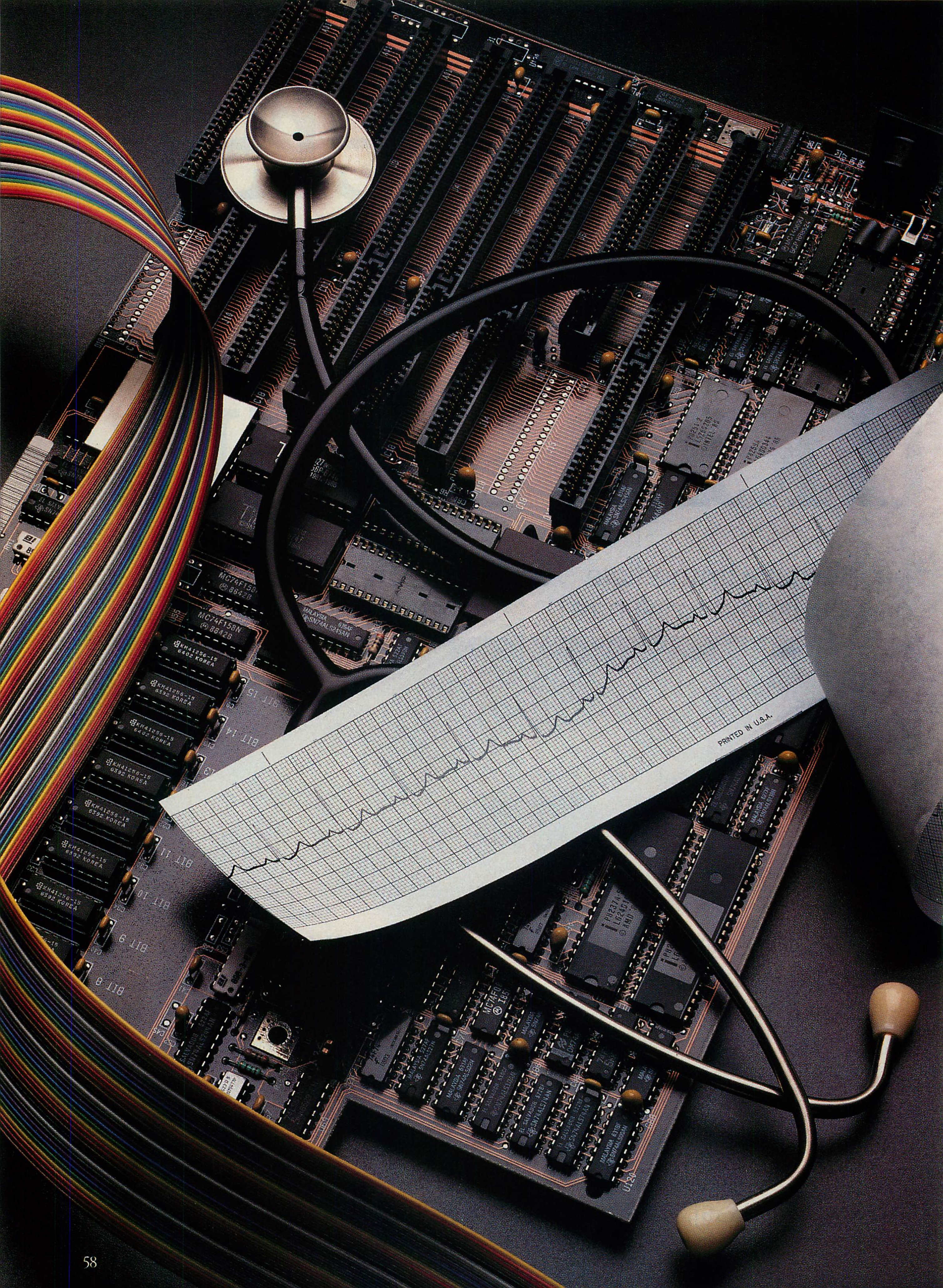
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Hardware Assistance

The Atron 386 Source Probe and Periscope III help developers detect bugs more quickly and reliably than software debuggers.

MARTY FRANZ

The very features that have made the personal computer such an unqualified success—its simplicity and accessibility—conspire against the software developer attempting to diagnose and repair bugs. Unlike mainframes and minicomputers, errant programming or defective hardware can easily corrupt PC operating systems, code space, data areas, and program stacks that reside in unprotected RAM. Even software debuggers can be overwritten by the very bug they are trying to locate and fix.

This problem has become magnified in the last few years, as PC operating environments have become more complex. Microsoft Windows, DOS device drivers, terminate-and-stay-resident (TSR) programs such as Borland's SideKick, LANs, and advanced hardware have combined to make finding and fixing complex hardware and software problems a frustrating experience.

The hardware-assisted debugger redresses two of the PC's architectural shortcomings that impede debugging. First, it hides the debugging software in write-protected memory where the program being debugged (target program) cannot overwrite it. Second, it monitors the signals between the CPU and the rest of the system and stops the program upon the occurrence of an event of interest—for example, the imminent overwriting of the interrupt table.

Atron's 386 Source Probe for classic-bus 80386 systems and The Periscope Company's Periscope III for 80286 systems are representative of the range of price and level of sophistication available in hardware-assisted debuggers. Because the two products support different types of hardware, they are not directly competitive products. Table 1 summarizes features of both.

HARDWARE TO THE RESCUE

Why should software developers or technical-support managers consider buying a hardware-assisted debugger? Both products reviewed here have hefty price tags. The Periscope III is $1,395 and the 386 Source Probe commands a princely sum of $4,295. Are these products, which cost as much as some entire systems, technical overkill? An answer to this question requires an understanding of what a hardware debugger can do that a software debugger cannot. (For a description of software debuggers, see "Turbo Debugging," Ben Myers, this issue, p. 46).

Developers use software debuggers to set breakpoints at specific locations in a program. The debugger saves a single byte at the break address and replaces it with a one-byte INT 3 instruction. When the program executes this instruction, control transfers to the INT 3 handler within the debugger; the handler restores the original contents of the break location, then displays the registers and waits for user input.

Two difficulties are apparent in this approach. First, the user must locate the area of the program where the suspected problem lies. Thus, a large part of a typical debugging session involves tracing through long stretches of well-behaved code in search of the

PHOTOGRAPHY • BRUCE WELLER

point of failure. Second, the operation of the software debugger depends on the integrity of three areas of memory: the location of the breakpoint, the interrupt vector table, and the memory containing the INT 3 handler. If the target program overwrites any of these areas, the system hangs.

A hardware-assisted debugger addresses one or both of these problems. Rather than relying on information inserted into the target program's code, this type of debugger can stop execution in response to events external to the program. More sophisticated products also protect the interrupt handlers, program code, and interrupt table.

All hardware-assisted debuggers have two components: a board that plugs into an expansion slot and software that contains the user interface and interrupt handlers. In its simplest form, the debugging board serves merely as a connector for a breakout switch. When the user presses the switch, the board issues a nonmaskable interrupt (NMI) that activates the debugger's INT 2 handler. This asynchronous method of stopping the target program allows the user to reactivate the debugger even if the program overwrites INT 3 breakpoints or disables the keyboard by masking off interrupts. IBM's Professional Debug Facility and Periscope II are examples of this type of debugger.

This technique, however, is not foolproof. The NMI signal raises INT 2, which many video adapters and hard-disk controllers use for their own purposes. If the debugger repoints this vector to its own code, video or disk I/O could cease to work. In most cases, however, such adapters periodically reclaim the INT 2 vector, rendering the breakout switch inoperative. Certain types of software (copy-protection programs, for example) intentionally alter the NMI response by repointing the vector or disabling the NMI signal. Although a program cannot instruct the CPU to ignore an NMI, it can gate off the signal (prevent it from reaching the CPU) by setting the NMI mask bit in the appropriate I/O port (its address varies in different PC models).

The next level of hardware sophistication is achieved by adding write-protected memory to the debugger board. This memory typically resides in an unused portion of the processor's address space (for example, the segments above the video buffer); parts of it also may be outside the system's normal address space, such as EMS memory. At a breakpoint, a process similar to the mapping of EMS memory moves the debugger code into system RAM. Periscope I is an example of this type.

TABLE 1: *Comparing 386 Source Probe and Periscope III*

	ATRON	PERISCOPE
PRODUCT	386 Source Probe	Periscope III
SOFTWARE VERSION	1.0	4.01
PRICE	$4,295	$1,395
FEATURES		
Protected memory	1MB	64KB
Trace buffer size (KB)	2,048	8,192
386 compatible	●	○
8088, 286 compatible	○	●
PS/2 compatible	○	○
Source debugging	●	●
Call traceback	●	○
Command macros	●	●
DOS independence	●	●
ASCII terminal	●	●
Dual monitor	○	●
HARDWARE BREAKPOINTS		
Breakout switch (NMI)	●	●
Memory read/write/fetch	●	●
Memory DMA	○	●
I/O port read/write	●	●
Address/port ranges	●	●
Data-qualified	●	●
Count-qualified	●	●
Sequence[a]	●	○
SOFTWARE BREAKPOINTS		
Code (INT 3)	●	●
Monitor (watchpoint)	●	●
386 debug registers	●	●

● = Yes ○ = No

[a] *The ability to set conditions that must occur in sequence before the breakpoint is taken.*

Both products have similar capabilities in terms of hardware debugging assistance. They are not competing products, because each is meant for different hardware.

The two products reviewed here represent the most advanced type of debugger. Both have bus-monitoring hardware to achieve a true hardware-breakpoint capability. Besides breakout switch connectors and protected memory, the add-in boards also carry an auxiliary microprocessor and custom logic that reacts to bus signals in realtime, raising an interrupt when a particular bus event occurs.

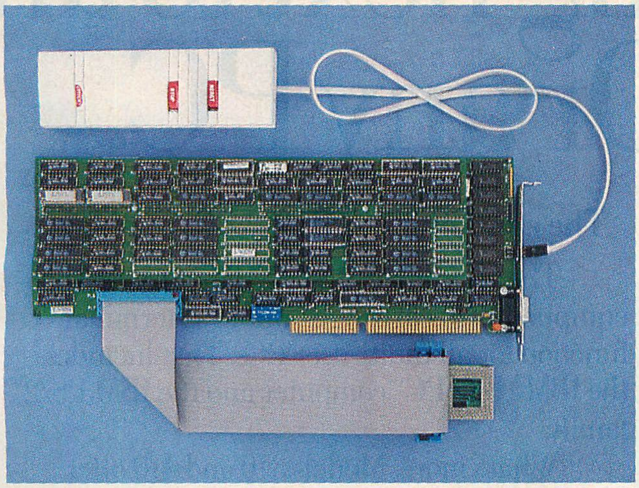
Typical breakpoint events include any or all types of access (read, write, DMA, instruction fetch) to a specified range of memory addresses or I/O ports. A pass count (stop only on the *n*th access) or a data value (stop only when reading or writing a certain value) further qualifies the breakpoint.

Although many software debuggers can break on a particular data value (Microsoft calls it a watchpoint in CodeView, Borland calls it a breakpoint in Turbo Debugger), they cannot run the target program at full speed while monitoring data values. Typically, a software debugger executes in single-step mode, executing the comparison code after every machine instruction. This is unsatisfactory for realtime programs, whose behavior depends on the speed of execution. The hardware debugger, on the other hand, runs the target program at full speed, using hardware logic to monitor the level of bus signals in realtime.

Another feature of the bus-monitoring debugger is a trace buffer that saves the last several kilobytes transferred on the bus. Thus, when a bus-event breakpoint occurs, the user can display the buffer to determine how the program got to that point.

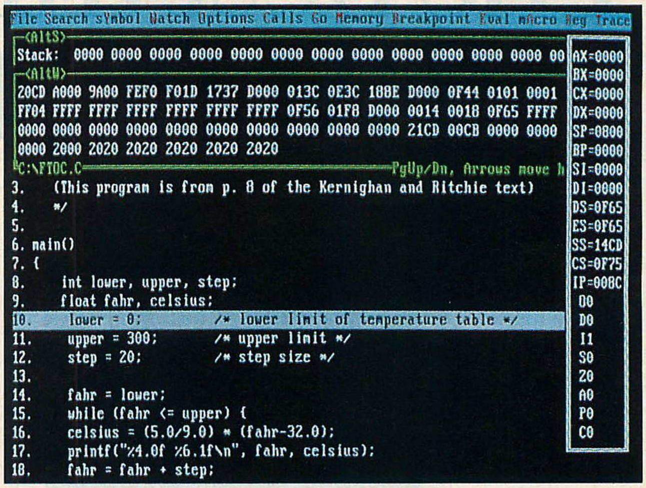
Compared with a software-only debugger, this powerful facility can drastically reduce the time spent hunting for persistent bugs. With a software

PHOTO 1: *Atron 386 Source Probe*



The 386 Source Probe's board installs in a slot and connects to the 386 socket on the system board. The size of the CPU connector makes it a tight fit in smaller system units. The white box carries reset and breakout switches.

PHOTO 2: *386 Source Probe Screen*



The 386 Source Probe's main window holds the disassembled or source code version of the program. Additional optional windows display the stack, watchpoints, and data areas. The menu at top displays top-level user commands.

debugger, the developer must examine the results of executed code at preselected sections of the program. This process is repeated over and over until the developer finds the section where the program fails. Depending on where the bug appears and how clever the developer is in choosing sections of the program to examine, this can be a long, arduous process. In contrast, an advanced hardware-assisted debugger finds the section of the program that causes the undesirable result, permitting the developer to spend more time actually fixing the problem instead of searching for it.

Because some debugging capabilities are built into the 386 chip, an add-in hardware debugger for a 386 system must provide additional functionality to justify its lofty price tag. The native debugging facilities include the ability to monitor four memory addresses for three types of access: read, write, and instruction fetch. When a specified access occurs at a specified address, the system executes an INT 1. These capabilities, although a great step over the INT 1 and INT 3 capabilities of 8088 and 286 processors, do not approach the power of add-in hardware debugger boards. Such boards add the ability to monitor access to a range of addresses or I/O ports, to break on the occurrence of specific data values, and to detect DMA as well as CPU-controlled reading or writing.

The utility of a hardware-assisted debugger is clear, but not all debuggers are created equal—what separates the capable from the competent? *PC Tech Journal* has established the following criteria for evaluating hardware-assisted debuggers:

- **Power and capability.** A useful debugger can look at and change the contents of data and code memory, and can set breakpoints at code locations or on events such as interrupts or specific bus activity. Moreover, it can debug pre-DOS and non-DOS programs and break out of any conceivable hang-up.
- **Ease of use.** This is a secondary consideration, because what a debugger can do is more important than how it operates. The ease of performing a particular operation, however, should be in direct proportion to its expected use. Ease of setup also is important. The user should not have to ravage a system in order to debug it.
- **Compatibility.** A debugger should work with the widest possible array of hardware.
- **Documentation.** Hardware debuggers often go unused until the panic sets in. Software developers may know a great deal about the application but not a lot about the underlying hardware. The documentation should be written for this type of user.

THE LATEST PROBE

The 386 Source Probe is Atron's latest hardware-assisted debugger. Like previous Atron products (PC Probe for 8088 systems and AT Probe for 80286 systems), it is designed to work with one type of microprocessor. Atron sells three versions of the product. The base model, called the 386 Probe ($3,995), comes with software to disassemble programs into assembly language; the 386 Source Probe ($4,295) adds software for source-level debugging of C programs, and the 386 Windows Probe ($4,595) has a module for debugging Microsoft Windows applications.

The 386 Source Probe consists of one diskette with debugger software, an adapter board with a plastic stop/reset switch box and attached cable, and a loose-leaf instruction manual (see photo 1). The documentation is organized into tabbed sections that explain hardware installation, starting the software, and advanced debugging. It also has an alphabetized command reference and an addendum on debugging under Windows. Documentation quality is adequate, but technical familiarity with debugging is required.

The 386 Source Probe's board is a full-length AT adapter with a piggyback board on top. Two ribbon cables lead to a socket for the 386 processor. On the back of the board are connectors for a standard-AT serial cable for attaching an ASCII terminal and the breakout/reset switch. The terminal can display debugger output while the main monitor displays target program output. The breakout switch has a stop button that sends an NMI to the debugger software and a reset button that resets the CPU but preserves the contents of on-board memory.

Installation of the software is easy. The user simply copies the files from the non-copy-protected diskette to a working directory and then creates a configuration file using any text editor.

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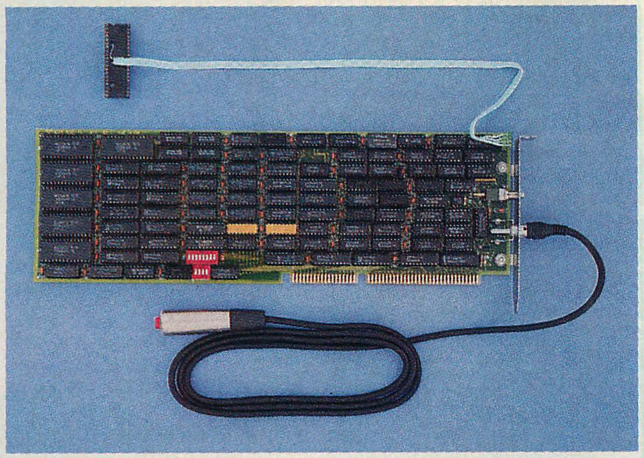
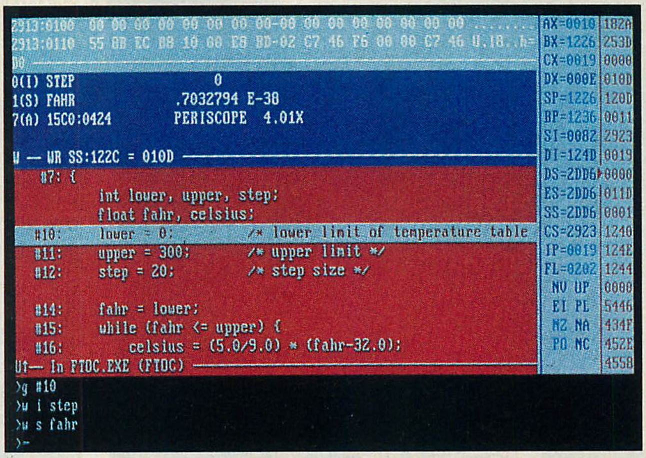
PHOTO 3: ***Periscope III***



The Periscope board gets most of its signals from an expansion slot, but needs a connection to the coprocessor socket to distinguish memory reads from instruction fetches.

PHOTO 4: ***Periscope III Screen***



Periscope III's horizontal windows, from top to bottom, display the start of the data segment, the watchpoints, the program code, and user commands.

Hardware installation can be quite an experience depending on the machine. The user must remove the 386 from the system board, plug a supplied ribbon cable connector into the empty socket, and mount the 386 on the connector. The other end of the ribbon cable, the breakout switch cable, additional logic probes, and an optional dumb-terminal serial cable plug directly into the Atron board.

The installation of the ribbon cable connector is a very tight fit in most systems. To help alleviate this problem, Atron supplies the connector in one of two orientations—one designed to fit the 16-MHz Compaq Deskpro 386 and the other for the Compaq Deskpro 386/20.

If the 386 chip is located under a disk drive, the user may need to disassemble much of the system to gain access to the CPU. For example, in the Deskpro 386/20e, the space between the CPU socket and the underside of the disk drive is insufficient to accommodate the height of the connector, so the drive-mounting assembly must be propped up at an angle (and the system unit cover left off) to provide adequate clearance. On the other hand, if the CPU socket is in front of the expansion slots, the height of the connector precludes the installation of full-length adapter boards in the two or three slots directly behind the socket.

This installation process may cause some users to lose faith; those who have not tackled any installation more complicated than a memory board should think twice before attempting to install the Atron board without knowledgeable assistance.

Two jumpers on the Atron board determine the two memory-block addresses that form windows into the 1MB of protected memory for the debugger software and symbol tables. To avoid conflicts with EMS, network adapters, or other controller cards, the user can set the window at any 16KB address between segments C400H and DC00H, and the 1MB of protected memory at any even megabyte boundary. A diagnostic program ensures that the card is functioning properly.

The 386 Source Probe is a complex product with complex interactions with its host system; the installation section of the manual does not attempt to cover all contingencies. Atron expects that most installers will need to call Atron's technical support for personalized help. Telephone support is prompt, courteous, and accurate.

To realize the added benefits of the Source Probe, the user must recompile the program with options that produce symbolic debugging information. Atron's boards use the Microsoft debugging information created by the /Zi (all symbolic information) and /Zd (source line numbers only) compilation switches. The user also should disable optimization with the /Od switch because this procedure can reorder program instructions, upsetting the correspondence between a sequence of machine instructions and the source statement from which they were generated. For programs generated by non-Microsoft compilers, the Atron software can obtain symbolic information from the linker-created .MAP files.

The 386 Source Probe's main screen window displays assembly language or C versions of the source; the latter is presented only if the source file is available and the program was compiled with symbolic debugging options. The base 386 Probe model displays only the assembly language view. The user also can define auxiliary windows to display the stack or portions of the data space (see photo 2).

Above the main window is a menu bar that features 13 options represented by single-letter abbreviations. Unfortunately, many of these abbreviations are not mnemonic and serve merely as accelerator keys in lieu of moving the cursor to highlight the desired choice. The letter *Y*, for example, is the abbreviation for sYmbol-related functions, because the letter *S* already designates the Search option. Choosing an option opens a drop-down menu box with several suboptions inside it. The up- and down-arrow keys highlight an option within the menu box, and Enter activates it.

Along with the menu bar and boxes, the function keys also are active. The F1 key displays concise single-screen help screens that summarize commands but contain no tutorial information. Other function keys toggle a register display window along the right-hand side of the screen that updates every time execution is stopped, switch the code window between source and assembly language views of the code segment, single step to the next instruction, and execute a source-level statement as opposed to a single machine instruction.

The 386 Source Probe has a variety of commands for manipulating files and symbol tables. The File option con-

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VALID function	Yes (1985)	No	Just Intro'd
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Null Character Support	Yes (1987)	No	No

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trols the loading of a program (.EXE) file or specifies a log file that saves the output of a debugging session for later. The Search option searches the current source file for strings, which is a big help when navigating through a large source file. The Symbol option displays, changes, and deletes symbols from a module. This option also limits the modules from which symbols are loaded and through which the program will single step.

The Watch option has comprehensive facilities for displaying code and data in a variety of formats. A watch window continuously displays the stack of a running program or key pointers and variables as the program single steps. Once defined, watches are stored in a file for use during the next debugging session.

Settings and preferences for the debugging session, controlled by the Options menu, include case sensitivity in string searches, the format of single-step listings, and the function-call protocol in effect. The 386 Source Probe supports Microsoft and Lattice function-call protocols.

The Calls option provides trace-back information for function calls, locates the caller in the source code, and optionally accesses the Search menu for further searching. The user can move up and down the calling stack to look at functions above and below the current function. A unique feature of the 386 Source Probe is the Variable suboption, which displays and changes local variables of any function whose stack frame is on the calling stack.

To restart execution of the program and set one-time (non-sticky) breakpoints in the code, the Go option is used. The non-sticky breakpoints execute the program up to the next debugging point. The stop button on the breakout switch can be used at any time to halt execution and return control to the debugger.

The Memory option displays and changes memory, I/O ports, and variables. The Variable suboption on this menu displays and modifies C variables by name, in a format corresponding to the type declaration in the source code. The 386 Source Probe also handles 80*x*87 floating-point numbers and displays and modifies data in this format, including NAN (not a number) and infinite values.

Although it sounds involved, the combination of function keys and menu selections works smoothly. With frequent use, the 386 Source Probe becomes a fast, convenient tool.

The 386 Source Probe permits the user to set a wide variety of breakpoints—an important selling point for any debugger. The user can define 10 sticky breakpoints with the Breakpoint menu. These remain in effect through any number of activations until explicitly cleared, whereas the debugger automatically clears non-sticky breakpoints, set with the INT 3 instructions, when the next breakpoint occurs.

The user can set hardware breakpoints on reading, writing, or instruction fetches from several address ranges; on any activity to a range of I/O ports; or on the occurrence of hardware interrupts. Memory and I/O breakpoints can be qualified by data values or pass counts. The value can include "don't care" bits (analogous to wild-card characters in file searches). On a hardware-interrupt breakpoint, the debugger gains control after the interrupt is acknowledged, but before the interrupt handler gets control. The user also can specify a sequence of several events that must occur in a specific order before a breakpoint is taken—a real advantage when trying to track down an obscure problem.

The 386 Source Probe permits the user to set a wide variety of breakpoints—an important selling point for any debugger.

Including the Go option, the debugger accepts a grand total of 4 hardware and 15 software breakpoints set at once. Hardware breakpoints, such as memory access traps and the breakout switch, produce an NMI.

The Evaluate option evaluates expressions calculator-style and reports the results in several radixes. The Macro option records keystrokes and saves them for later playback. An often overlooked nuisance in complex debugging jobs is the need to reenter dozens of commands to set up and cause a problem. The Register option displays (and allows the user to modify) the 386 registers, including those of a math coprocessor.

Like the Breakpoint option, the Trace option uses the hardware on the card. As the program executes, the card stores a bus history into protected RAM. The Trace option dumps CPU activity in either processed or unprocessed form; the former presents the bus events in order of execution, the latter in the order they occurred in the prefetch queue. The debugger displays the contents of the trace buffer in disassembled or raw hexadecimal format.

Atron provides a driver to debug non-DOS and pre-DOS programs that activates the Source Probe during bootup, when DOS is not present, to perform the services needed by the software portion of the debugger. The user also can load a program's symbol table independently of its code to debug previously installed TSRs.

PERISCOPING PROBLEMS

The Periscope Company makes several debuggers for PC- and AT-class machines. Periscope I resides in a 56KB protected-memory board and has an NMI breakout switch. Periscope II does not have the memory board, but has a breakout switch that does not require an expansion slot because it has a connector that slides into an occupied slot.

The Periscope III hardware-assisted debugger (see photo 3) is the flagship of the Periscope line. The model reviewed here has hardware breakpoints, a trace buffer, 64KB of protected RAM, and a breakout switch. It is designed for 8088 and 286 systems running as fast as 10 MHz, but does not work in 386 systems. Periscope III includes a non-copy-protected diskette containing the debugger software, an adapter board, an umbilical socket for a 287, a remote breakout switch, and a manual.

The manual (246 pages, nicely typeset and indexed) contains an installation section, a tutorial section, and several chapters on the various utilities. Some sections of the manual are somewhat disjointed and, like the Atron documentation, it assumes that the user is experienced at debugging.

Like the 386 Source Probe, software installation is the easy part. After backing up the diskette for safekeeping, a configuration program accomplishes the entire installation. The manual recommends removing any device drivers or TSRs from the system before running the configuration program. The program generates the version of Periscope needed (based on the hardware purchased) and copies the required files to a subdirectory called PERI.

To install the hardware, the user must set switches on the Periscope III board for the I/O ports and memory address and insert the board in an expansion slot. One DIP switch on the

board controls the I/O port address; it provides unusual flexibility by allowing any address divisible by four between 000H and 3FCH. The other controls the starting address of the 64KB of protected memory (the default is D000H; the board can be set for any 64KB boundary in the first 1MB.)

The Periscope III board does not function correctly unless the user connects a cable between it and the 287 socket, even if a 287 coprocessor is not installed in the system. This is because the board uses a pin on the 8087 or 287 to determine if a memory read is an instruction fetch. This signal is not available on the expansion bus and is more easily obtained from a pin on the coprocessor than from the CPU.

After hardware installation, a diagnostic program checks to ensure that the board is functioning properly. The only problem encountered during installation was that a Leading Edge EGA using INT 2 to emulate CGA mode caused a conflict with Periscope's NMI vector, disabling the breakout switch. After turning off the emulation, Periscope functioned perfectly. A similar problem exists with any video adapter that uses this type of emulation.

Periscope loads as a TSR into memory, to be activated either by the breakout button or the RUN loader utility. Like the 386 Source Probe, Periscope can debug source lines and use .MAP files produced by Microsoft's LINK for symbols. The TS.COM utility converts some types of .MAP files into a .PSS (Periscope symbol) file that Periscope can then load as its symbol table. The .MAP files produced by Phoenix's PLINK, Microsoft's LINK, and Digital Research's LINK86 must be processed with TS.COM, as do programs compiled with Aztec C, DeSmet C, and Microsoft C with the CodeView link option (/CO). Periscope fully supports the debugging information provided by the /Zi or /Zd options of Microsoft compilers.

Periscope's output display divides the screen into several windows (see photo 4). One contains the source code to the target program in either assembly or source language. A vertical window shows the stack; an indicator shows where the BP register is pointing. Still another window displays a chunk of memory in hexadecimal and ASCII. Periscope also has windows for watches, registers, and commands and help information.

Terse one- or two-letter commands, which are similar to, but much more powerful than DEBUG's commands, manipulate what information the windows display. The commands are maintained in a 512-byte circular buffer that the user can scroll through, allowing prior commands to be recalled, edited, and reissued.

The main function keys control screen swapping between Periscope and the target program and permit DOS-style command editing. The Alt function keys save the current command line as a macro; the corresponding Ctrl function key recalls and executes it. Like Atron's macro facility, this eases the developer's problem of repeating tedious commands when debugging a program.

All Periscope hardware uses the same software, so some of the functions are duplicated in software-only and hardware-assisted forms. For example, either the software (slowing down the program under test) or the bus-monitoring hardware (realtime) monitors breakpoints on memory accesses. True hardware breakpoints monitor any access (read, write, DMA, or fetch) on a range of memory or block of I/O ports and can qualify each breakpoint by a pass count or data value.

All Periscope hardware uses the same software, so some functions are duplicated in software-only and hardware-assisted forms.

The trace buffer accommodates 8,192 bus events and displays instruction fetches, data transfers, or both. The user can limit the contents of the buffer to events of interest, allowing the capture of widely spaced events. One possible breakpoint is a buffer full of either consecutive or filtered events. In consecutive events, the program stops in any of three conditions: when a specified event is at the beginning, midpoint, or end of the trace buffer. This allows the user to determine how a program reached a certain point and where it went.

Periscope has facilities for debugging pre-DOS and non-DOS programs and for user-written routines. The user can write routines to run when a breakpoint occurs, when the program terminates normally, after every Periscope command, or as part of a boot sequence. These routines cannot perform DOS functions, because the interrupts that invoke them might occur while execution is within a DOS function, and DOS is not reentrant. To handle this, Periscope has a replacement set of services the routine can use, such as displaying a string and searching the program's symbol table. Control is passed to the user routine via a software interrupt in the range 60H to FFH, with the registers specifying the type of processing to perform.

Periscope permits the developer to debug programs on ASCII terminals. The file PSTERM.TXT contains the keyboard and display mapping, control characters, and communications parameters. This alternate display is selected when Periscope first starts. Periscope also supports two-display systems for debugging; one displays Periscope and the other displays the target program.

HOW BIG IS THE PROBLEM?

Periscope's major drawback is a narrow range of compatibility; it runs only on PC- or AT-bus 8088 and 286 machines running no faster than 10 MHz. If those are the target machines, Periscope III is a good value.

The Atron 386 Source Probe has a wide array of features. Only the price and the relatively messy installation (potentially hazardous to the integrity of the fragile pins of the 386 chip) might be cause for second thoughts. This product, however, is a great help in developing software for the brave new world of the 386.

Both debuggers are excellent products for the machines they are designed for. Considering the lack of alternatives, they are invaluable for solving certain kinds of problems. Which one you select depends on the machine you use most.

Atron, a division of Micro Case
Saratoga Office Center
12950 Saratoga Avenue
Saratoga, CA 95070
408/253-5933
386 Source Probe: $4,295
CIRCLE 332 ON READER SERVICE CARD

The Periscope Company Inc.
14 Bonnie Lane
Atlanta, GA 30328
404/875-8080
Periscope III: $1,395
CIRCLE 333 ON READER SERVICE CARD

Marty Franz is a programmer for Allen Test Products, a division of The Allen Group Inc., located in Kalamazoo, Michigan.

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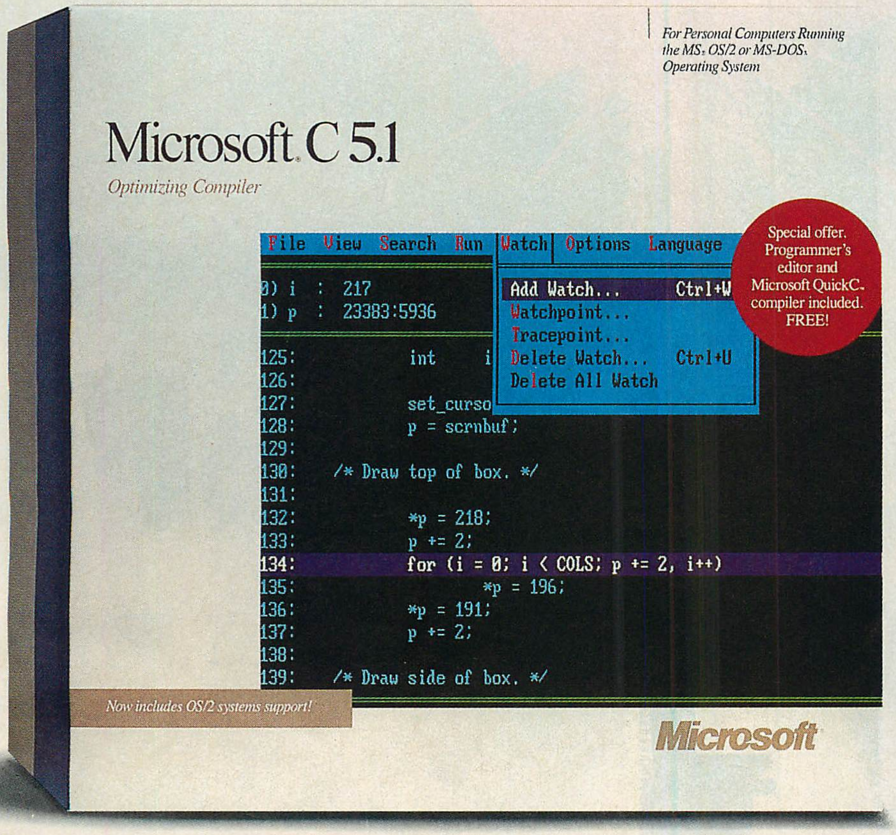

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COMPUTER SYSTEMS

The VGA Parade

Filing out in a steady stream are dozens of add-in boards that emulate and enhance the VGA standard. Seven of the highest-performance boards show their true colors.

KENT QUIRK

Competition is fierce among vendors of Video Graphics Array (VGA) add-in boards. IBM's PS/2 Display Adapter and Compaq's Video Graphics Controller (VGC) were the first out of the gate and set a stiff pace for the rush of boards to follow.

On the heels of its review of the IBM and Compaq boards (see "The VGA Compatibility Test," Ed McNierney and Kent Quirk, November 1988, p. 49), *PC Tech Journal* applies its suite of VGA compatibility tests to evaluate seven 16-bit VGA boards. They are the Allstar Microsystems Peacock, AST VGA Plus, Hewlett-Packard D1180A VGA, Tatung VGA, Tecmar VGA/AD, Video Seven V-RAM VGA, and Western Digital Imaging Paradise VGA Professional. Table 1 compares the features of these VGA boards to the IBM and Compaq boards.

The VGA compatibility tests are designed to compare VGA add-in boards to the IBM system-board VGA and to each other. With square pixels, higher resolution, and an improved register set, the VGA standard has rectified the worst problems of the earlier EGA. Each board is examined for quality of hardware, software, and documentation and tested for compatibility.

Performance is compared using the text-scrolling, window/scrolling, and 16-color graphics tests from the *PC Tech Journal* system benchmark suite (see "High-Level Measurements," Kent Quirk, September 1988, p. 54).

All boards were installed and tested in an 8-MHz IBM AT 339. Table 2 shows the relative performance of each board expressed as a percentage of the performance of the IBM PS/2 Display Adapter. These boards have 16-bit interfaces and perform better than the IBM board with its 8-bit interface.

The ability of the boards to function properly in a multitasking environment is tested by using them to run IBM OS/2 Standard Edition version 1.1 (which includes Presentation Manager) and Microsoft Windows/386. As expected from their compatibility test results, both the IBM VGA and Compaq VGC boards work fine with OS/2 and Windows/386.

Not surprisingly, the IBM and Compaq boards are very compatible with the system-board VGA, although even the IBM board differs slightly. In addition to the higher performance provided by the 16-bit interface, these seven VGA boards offer enhanced text and graphics features, including explicit support for monitors other than ones designed specifically for the VGA, additional modes with resolutions as high as 1,024-by-768 pixels for these monitors, and automatic detection and emulation of earlier-standard video modes, such as CGA and Hercules (see table 1).

These seven boards use only three VGA chip sets among them. Three use the Paradise chip set, two use Video Seven's, and two use hardware from Tseng Laboratories. Features and software for each of the chip sets are similar, but each board vendor adds its own custom features and support.

Although the VGA chip set is the core of its design, a VGA board can incorporate other components. IBM, for example, provides a *feature connector*, which has no products available for it at the moment but could be used to add extra resolution or other advanced features. Most of the manufacturers provide IBM-compatible feature connectors, just in case. The IBM board also has connectors for attaching a daughterboard. Only Video Seven emulates IBM's add-in board in size, shape, and daughterboard connectors.

PHOTOGRAPHY • DON CARSTENS

PHOTO 1: *Allstar Microsystems Peacock*

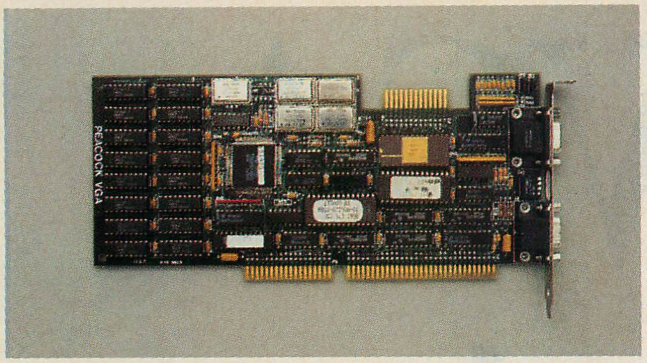

PHOTO 2: *AST VGA Plus*

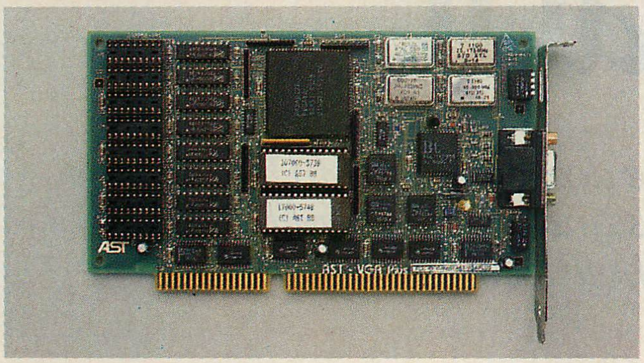

PHOTO 3: *Hewlett-Packard D1180A*

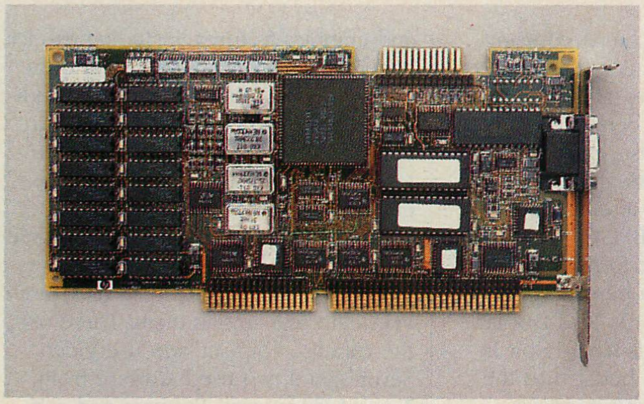

PHOTO 4: *Tatung VGA*

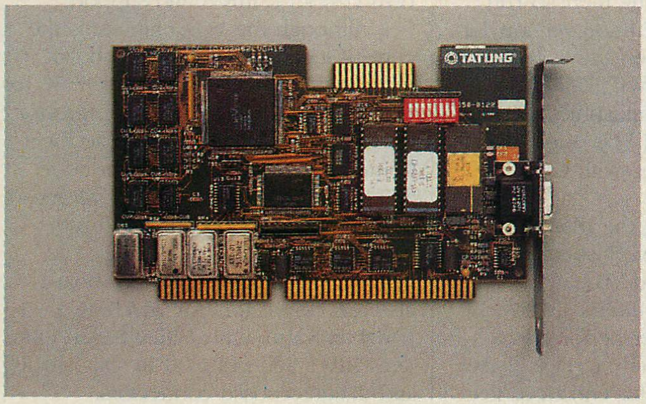

PHOTO 5: *Tecmar VGA/AD*

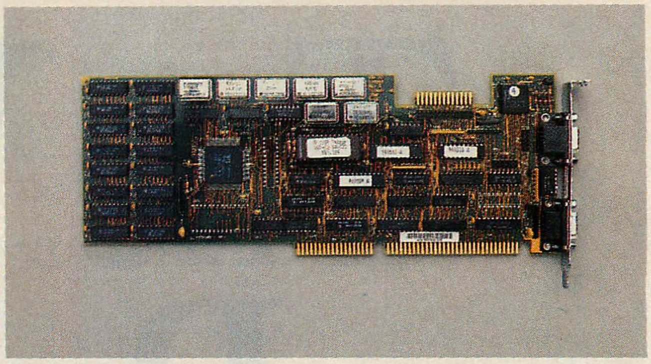

PHOTO 6: *Video Seven V-RAM VGA*

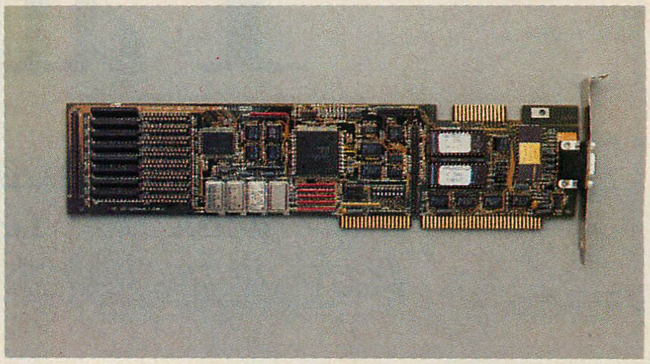

PHOTO 7: *Western Digital Paradise VGA*

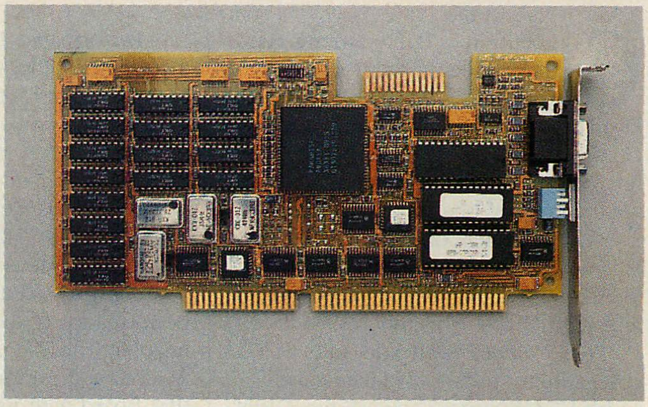

Photo 1: Peacock has a surface-mounted Tseng Laboratories VGA chip and both 9- and 15-pin display connectors.

Photo 2: VGA Plus's Paradise VGA chip is surface mounted. It has 256KB of RAM, with sockets for another 256KB.

Photo 3: The HP D1180A board uses a Paradise VGA chip and is available with either 256KB or 512KB of RAM.

Photo 4: The Tatung VGA's Video Seven VGA chip and 256KB of RAM are all surface mounted on the board.

Photo 5: VGA/AD uses a surface-mounted Tseng Laboratories VGA chip. It provides 9- and 15-pin display connectors.

Photo 6: The V-RAM VGA is the same size as IBM's VGA add-in board, but allows 512KB of dual-ported RAM.

Photo 7: The VGA Professional board uses a surface-mounted Paradise VGA chip and comes with 512KB of RAM.

ALLSTAR PEACOCK

The Peacock offers a great deal of flexibility for about the same price as the Compaq VGC. It offers several enhanced resolution modes, and it can be used with existing digital as well as the new analog VGA displays.

The board has a 9-pin DIN connector as well as the standard 15-pin VGA connector. The 9-pin connector allows the use of CGA, EGA, and monochrome monitors (at their normal resolutions) as well as VGA monitors.

A 9.25-inch-long XT-height board, the Peacock's rear bracket contains an opening through which users can manipulate a set of four DIP switches to specify monitor configurations.

The board's VGA chip and ROM BIOS are both from Tseng Laboratories. It is available with either 256KB (which is standard on the IBM system-board VGA) or 512KB of RAM. For users programming the board directly, the additional video memory allows higher graphics resolution, more colors, and more pages of text or a single larger page to be scrolled under program control.

The Peacock supports a range of text video modes beyond those found on the IBM system-board VGA, including character/line combinations of 80-by-60, 100-by-40, 132-by-25, 132-by-28, and 132-by-43. Fonts provided are simple but adequate.

Enhanced graphics modes of 600-by-800 pixels and 1,024-by-768 pixels are available, but the information required for programmers to use them is not provided; this limits their use to the device drivers provided by Allstar for specific applications such as Autodesk's AutoCAD. The board also has hardware zoom ability in graphics mode. Once zoomed, the image can be panned across the displayed area. A terminate-and-stay-resident (TSR) utility called HOTZOOM allows the user to zoom in on any portion of a graphics image and scroll the image around the zoomed area.

Unlike the IBM and Compaq add-in boards, the Peacock supports the vertical-retrace interrupt (INT 2), which allows programs to update the screen image during the vertical-retrace interval without constantly monitoring VGA status registers. This feature is compatible with the IBM VGA system board, but its use can conflict with other expansion boards, such as network adapters, that use INT 2.

Software and documentation. Allstar supplies device drivers for Autodesk's AutoCAD, Lotus Development Corporation's 1-2-3 and Symphony, Digital Research Inc.'s GEM, Xerox Corporation's Ventura Publisher, and Microsoft Windows. Allstar's pair of TSR programs, HOTZOOM and HOTKEY, control the pan and zoom from the keyboard or from software. Users cannot install the software interface, however, without also installing the keyboard interface.

A font-loading utility and powerful font editor create and modify fonts, including those used with extended video modes and a sample APL font.

The VMODE utility switches among all supported video modes, including EGA, CGA, monochrome display adapter (MDA), and Hercules emulation. The board comes with a replacement for the ANSI.SYS device driver; it can handle all extended modes, a video BIOS speed-up driver, and a diagnostic program (which also acts as a demonstration program).

Allstar's documentation provides detailed information on configuration and installation. Missing from the documentation is an explanation of how to use the Peacock's high-resolution modes, although it includes information on interfacing programs with the pan and zoom functions.

Compatibility and performance. The Peacock had numerous compatibility problems. One of them was major—the BIOS would not set up the characters for the multiple font test. Several video-mode failures occurred, including the common problem with writing color 0 text in mode 11H, which is shared with the Compaq VGC. Some differences in CRTC register parameters were also evident (see table 2).

The Peacock's compatibility in monochrome mode is particularly poor with respect to the digital-to-analog converter (DAC). It is obvious from watching the screen that the DAC has different values from the ones IBM uses, but the compatibility test could not read or write the Peacock's DAC in monochrome mode. Monochrome mode also exhibited the common mode 0DH text writing failure.

Despite these problems, the Peacock functioned satisfactorily with OS/2 version 1.1 and Windows/386 in standard VGA resolution modes. It also worked correctly with Windows 2.0 in standard VGA modes and in 800-by-600 pixel graphics mode.

The Peacock was one of the slowest boards tested when used in 16-bit mode, performing the text-scrolling test only 35 percent faster than the 8-bit IBM VGA add-in board. This poor performance results because Allstar requires the use of a RAM BIOS driver in order to deliver full 16-bit BIOS performance. The Peacock performs text operations twice as fast as the IBM add-in board (but not as fast as the Compaq VGC) with the driver loaded, but at a cost of 32KB of valuable RAM.

The Peacock would be useful for an OEM wanting to take advantage of the extended video modes and pan and zoom with custom software, or for someone needing a board that supports digital monitors. Because of its compatibility failures, the Peacock is not recommended for the casual user.

AST VGA PLUS

The AST VGA Plus offers an array of features and very good performance. Its enhanced features are hindered by its inability to initiate 16-bit operation automatically and the high price ($941) of its 512KB version.

From the well-known add-in board manufacturer, AST, this board features the Paradise chip set used on the Compaq board. The BIOS is a joint AST-Western Digital effort. The VGA Plus is a 7.25-inch-long, XT-height board with a single 15-pin connector on the back panel and a set of DIP switches. The board has the standard allotment of 256KB of RAM and an extra row of empty sockets for upgrading to 512KB. This is the only board tested that has no IBM-compatible feature connector, precluding the use of future VGA enhancements that make use of the connector.

Beyond the normal VGA modes, the VGA Plus supports graphics modes with as many as 800-by-600 pixels and 16 colors, and text modes with as many as 132 characters by 43 lines. If 512KB of RAM is installed, it supports 640-by-480 pixels with 256 colors.

Software and documentation. AST supplies a diskette of device drivers for AutoCAD, GEM, Windows, Lotus, CalComp Inc.'s CADVANCE, and Ashton-Tate's Framework II. AST also includes instructions for using extended video modes with MicroPro International's WordStar and WordPerfect Corporation's WordPerfect.

TABLE 1: *VGA Board Features*

	IBM	COMPAQ	ALLSTAR	AST RESEARCH	HEWLETT-PACKARD	TATUNG	TECMAR	VIDEO SEVEN	WESTERN DIGITAL
PRODUCT	VGA	VGC	Peacock/ 16	VGA Plus	D1180A	VGA	VGA/AD	V-RAM VGA	Paradise VGA Professional
PRICE[a]	$595	$599	$495/ $595	$599/ $941	$445/ $595	$399	$545	$899/ $1,194	$799
SPECIFICATIONS									
Chip set	IBM	Paradise	Tseng	Paradise	Paradise	Video Seven	Tseng	Video Seven	Paradise
Video RAM (KB)	256	256	256/512	256/512	256/512	256	512	256/512	512
Bus interface (bits)	8	16	16	8/16	8/16	16	16	16	8/16
Display connector (pins)	15	15	9/15	15	15	15	9/15	15	15
Warranty (years)	1	1	2	2	1	1	2	5	3
Feature connector	●	●	●	○	●	●	●	●	●
Diagnostics	●	●	●	●	●	●	●	●	●
Automatic 16-bit operation	N/A	●	●	○	○	●	●	●	●
Vertical retrace interrupt	○	○	●	○	○	●	●	●	○
Hardware zoom	○	○	●	○	○	○	○	○	○
OS/2 COMPATIBILITY	●	●	●	●	●	●	●	●	●[b]
EMULATION MODES									
CGA	○	○	●	●	●	●	●	●	●
EGA	○	○	●	●	●	○	●	●	●
MDA	○	○	●	●	●	○	●	●	●
Hercules	○	○	●	●	●	●	●	●	●
ENHANCED 16-COLOR TEXT MODES (columns/rows)									
80-by-43	○	○	○	○	○	40H	40H	40H	○
80-by-60	○	○	26H	○	○	43H	○	43H	○
100-by-40	○	○	2AH	○	○	○	○	○	○
100-by-60	○	○	○	○	○	44H	○	44H	○
132-by-25	○	○	24H	55H	55H	41H	17H	41H	55H
132-by-28	○	○	23H	○	○	45H	○	45H	○
132-by-43	○	○	22H	54H	54H	42H	○	42H	54H
ENHANCED RESOLUTION GRAPHICS MODES (pixels)									
640-by-400, 16 colors	○	○	○	○	○	○	14H	○	○
640-by-350, 256 colors	○	○	○	○	○	○	1AH	○	○
640-by-400, 256 colors	○	○	○	5EH	○	66H	1BH	66H	5EH
640-by-480, 256 colors	○	○	●[c]	5FH[c]	5FH[c]	○	1CH	67H[c]	5FH
752-by-410, 16 colors	○	○	○	○	○	60H	○	60H	○
720-by-540, 16 colors	○	○	○	○	○	61H	○	61H	○
720-by-540, 256 colors	○	○	○	○	○	○	○	69H[c]	○
800-by-600, 2 colors	○	○	○	59H	59H	○	○	○	59H
800-by-600, 16 colors	○	○	29H	58H	58H	62H	16H	62H	58H
800-by-600, 256 colors	○	○	●[c]	○	○	○	1DH	○	○
1,024-by-768, 2 colors	○	○	○	○	○	○	○	63H	○
1,024-by-768, 4 colors	○	○	○	○	○	○	○	64H	○
1,024-by-768, 16 colors	○	○	●[c]	○	○	○	18H[c]	65H[c]	○

● = Yes ○ = No
N/A = Not Applicable
nnH = Video mode (hexadecimal)

[a] *Prices are with 256KB of video RAM, except for Tecmar and Western Digital boards, which come with 512KB. Second price, if given, is with 512KB.*
[b] *When configured to support a VGA rather than a multifrequency display.*
[c] *512KB RAM required.*

The 16-bit VGA boards offer enhanced text and graphics features and also promise close compatibility with the IBM VGA standard. The IBM VGA add-in board and Compaq VGC are included here for comparison with the other seven boards.

TABLE 2: *Compatibility and Performance Test Results*

	IBM	COMPAQ	ALLSTAR	AST RESEARCH	HEWLETT-PACKARD	TATUNG	TECMAR	VIDEO SEVEN	WESTERN DIGITAL
PRODUCT	VGA	VGC	Peacock	VGA Plus	D1180A	VGA	VGA/AD	V-RAM VGA	Paradise VGA Professional
SPECIFICATIONS									
BIOS date	10/27/86	02/17/88	07/20/88	06/13/88	04/21/88	09/29/88	09/21/88	07/13/88	05/23/88
BIOS copyright	IBM	Compaq	Tseng	AST/ Paradise	Paradise	Video Seven	Tecmar	Video Seven	Paradise
Chip set	IBM	Paradise	Tseng	Paradise	Paradise	Video Seven	Tseng	Video Seven	Paradise
BIOS COMPATIBILITY									
Mode support	●	●	●	●	●	●	●	●	●
Cursor operation	●	●	●	●	●	●	●	●	●
Light-pen support	●	●	●	●	●	●	●	●	●
Multiple pages	●	●	●	●	●	●	●	●	●
Screen scrolling	●	●	●	●	●	●	●	●	●
Text I/O	○(A)	○(A,B)	○(B)	○(C)	○(A)	○(A,B)	○(A)	○(A,B)	○(A)
Graphics I/O	●	●	●	●	●	●	●	●	●
Palette/DAC	●	●	○(D)	●	●	●	●	●	●
Save/restore video	●	●	●	●	●	●	●	●	●
Character generator	●	●	○(E)	●	●	●	●	●	●
Alternate select	●	●	●	●	○(F)	○(F)	●	●	●
Data areas	●	●	○(G)	●	●	●	○(G)	○(G)	●
HARDWARE COMPATIBILITY									
General registers	○(H,I)	○(H,I)	○(J)	○(H,I)	○(H,I)	○(H)	○(H,K)	○	○(H,I)
DAC registers	●	●	○(L)	●	○(M)	○(L,M,N)	○(L,N)	○(L,M,N)	●
Sequencer registers	●	●	●	●	●	●	●	●	●
CRTC registers	●	○(O)	○(O,P)	●	○(O)	○(Q)	○(O,P)	●	○(O)
Graphics registers	●	●	●	●	●	●	●	●	●
Attribute registers	●	○(R)	●	○(R)	○(R)	○(R)	●	○(R)	○(R)
RELATIVE PERFORMANCE (to IBM VGA)									
Text scrolling	100	251	135	231	164	216	162	216	164
Window/scrolling	100	247	117	216	149	207	154	207	150
Graphics	100	110	105	111	111	114	102	115	111

All boards except IBM VGA were tested in 16-bit mode.

● = *Pass* ○ = *Fail*

COMMENTS

A. Monochrome mode: text writing failure in mode 0DH.
B. Fails to correctly implement text written in color 0 in mode 11H.
C. Fails to correctly implement fonts in modes 4 and 5. Text read/write fails.
D. The DAC and Palette were completely unreadable through BIOS functions.
E. The system hung while attempting to change fonts (never returned from a BIOS call).
F. Implements more than IBM does in alternate BIOS data areas.
G. The dynamic state area differs from IBM's. This should not cause any problems.
H. Shows 10H instead of 70H in input status register 0. Use of these bits is reserved by IBM.
I. Fails to provide hardware interrupt on vertical interval.
J. Shows 50H instead of 70H in input status register 0.
K. The value in the (currently unused) feature control register is different from IBM's. Not likely to cause a problem.
L. DAC read/write errors.
M. Assigns color values to the upper palette registers that IBM left set to zero.
N. The DAC palette loaded in monochrome mode is wrong.
O. Minor errors in cursor size in emulation modes. Usually off by one line.
P. Minor variations found in CRTC register values. This could cause marginal monitors to lose synchronization.
Q. The board defaults to enabling the vertical retrace interrupt. This increases the chance of a random system crash.
R. In the attribute registers test, horizontal scrolling was jerky rather than smooth. The chips buffer a register write until the next vertical interval, rather than IBM's method of doing it immediately. Appropriate programming steps can be taken to work around this problem.

All of the boards (even the IBM add-in board) are to some degree incompatible with the IBM PS/2 system-board VGA. Many of them exhibit slight variations when used with a monochrome monitor, but this is not likely to be a problem for most users.

A utilities diskette contains a diagnostic program, a video BIOS speed-up program, a mode-setting program called ASTVGA, and a VGASETUP program for displaying correct switch settings to install the VGA board in any given system.

Before installing the AST VGA, the user must set a switch on the board that specifies 8- or 16-bit access to the board's VGA ROM BIOS. Running the AST VGA Plus in 16-bit mode requires that no other boards be installed in the space from C0000H to DFFFFH. (This excludes most hard-disk drives, expanded memory boards, and network boards.) Both Western Digital and AST manuals include dire warnings about using 16-bit mode in systems that do not meet this criterion.

The reason for AST's conservative approach using 16-bit mode operation has to do with basic architectural features of the IBM AT expansion bus. On an AT-compatible bus, a hardware signal exists called −MEM CS16, which an add-in board can use to indicate that it will perform a 16-bit transfer. From the time an address appears on the bus, the board has a short time to determine whether the address applies to that board and whether or not a 16-bit transfer will be performed. Some of the highest bits of the address appear first; they specify the address to the nearest 128KB boundary, and according to IBM's AT specification, an add-in board must decide whether or not it activates −MEM CS16 based only on this information.

AST has implemented the AT specification to the letter. Boards from the other manufacturers provide an autosense feature to determine when to use 16-bit mode. This feature measures bus performance at boot time to determine if the board can push the bus specification by waiting until the entire address appears before asserting the −MEM CS16 line. Most of these boards allow the user to force 8-bit mode if autosense is not working properly.

The manual for the VGA Plus has a quick-installation fold-out page and well-written text explaining the features of the board, installation, and the drivers with which it is equipped. The manual is a set of 75 punched sheets to be inserted into an IBM-style binder.

Compatibility and performance. Through the ASTVGA program, the VGA Plus supports emulation of the EGA, CGA, MDA, and Hercules boards. However, the CGA emulation uses incorrect font data in graphics modes; any text displayed is unintelligible.

The AST, Hewlett-Packard, and Western Digital boards all share a difficulty—if a Microsoft mouse driver is loaded, changing to an emulation mode causes the screen to go blank. The AST mode-setting utility blanks the screen as soon as the emulation mode is invoked; however, the Paradise driver can change modes without blanking the screen—only when the program exits does the problem occur.

Western Digital documents the problem in a README file on the Paradise board's utility diskette. To get around this difficulty, the user (with the mouse driver not loaded) must set the video mode, lock it, and reboot the system in the current mode.

AST provides a diagnostic program, DIAG, with VGA Plus that is useful for testing the board's operation. However, this program leaves the board in a state such that it fails several of the VGA compatibility graphics tests and causes Microsoft Word to place the board in a very low-resolution mode. Turning the system off and on again returns the board to its normal state.

The AST board failed to correctly implement text fonts in modes 4 and 5, which are the CGA color graphics modes. In monochrome mode, the VGA Plus had the same compatibility failures as the IBM system-board VGA. Finally, the VGA Plus (as well as the IBM add-in board, the Allstar Peacock, and Tecmar VGA/AD) failed the horizontal scrolling test by causing obvious jerking motion.

The VGA Plus worked fine with OS/2 version 1.1 and Windows/386 at standard VGA resolutions. It also worked correctly with Windows 2.0 in standard VGA modes and in 800-by-600-pixel graphics mode.

The AST board is fast, second only in speed to the Compaq VGC. Its good performance and minor compatibility problems make it worthwhile at $599 for the 256KB version, but rather expensive at $941 for the 512KB version.

HEWLETT-PACKARD D1180A

The D1180A from computer manufacturer Hewlett-Packard (HP) has many features and good compatibility for a good price. Its speed is not impressive, however, and its price advantage may disappear when compared with discounted prices that are available on other boards.

Like the Compaq VGC, the D1180A is designed to work with the company's own systems but works equally well with other XT and AT compatibles.

The D1180A uses the Paradise chip set. The 8.75-inch-long XT-height board is available with 256KB or 512KB of RAM. The D1180A has three connectors for attaching a daughterboard, which are different from those used on the IBM VGA add-in board. It supports the same advanced modes as AST and Western Digital (except 600-by-400 pixels with 256 colors), including four text modes with as many as 132 characters by 43 lines (in monochrome or color), and graphics modes of 800-by-600 pixels with 16 colors and 640-by-480 pixels with 256 colors (the latter requires 512KB of RAM).

Like the AST board, 16-bit operation must be selected manually by setting a jumper on the board.

Software and documentation. The D1180A is the only VGA board tested that provides its software utilities and drivers on both 3.5- and 5.25-inch diskettes. The drivers provided include AutoCAD, CADVANCE, and Microsoft Windows (version 1.*x* only); the manual has instructions for using WordPerfect and WordStar.

Software is nearly identical in appearance and operation to that shipped with the AST board. A program called HPVGA allows setting the VGA modes, including EGA, CGA, MDA, and Hercules emulation.

The FONTLOAD utility delivers Norwegian- and Danish-language fonts and IBM-compatible fonts. The latter are identical to fonts installed in the board's ROM BIOS.

The documentation is limited in that installation instructions cover only HP products. The board comes set to 8-bit mode (which works in all HP computers). The 16-bit mode is described only in an appendix and must be enabled with a DIP switch accessed from within the PC's case. The documentation does a good job of covering installation in HP computers, but says nothing about switch-setting when installing the board in an IBM computer.

Documentation is stapled and punched for an HP binder, which has pages that are wider than an IBM-style binder. This can be inconvenient for non-HP system owners.

Compatibility and performance. The D1180A shares with the IBM add-in board cleared-reserved bits in the input status register 0. The D1180A-assigned values to the DAC registers, which the IBM board sets to zero, had a single

failure in cursor-emulation mode and failed to execute the horizontal scrolling test smoothly. These errors also occurred in monochrome mode. Another problem (which the HP, AST, and Western Digital boards all share) is that the screen goes blank when changing to an emulation mode if the mouse driver is loaded.

The D1180 worked fine with OS/2 1.1, Windows/386, and Windows 2.0 in standard VGA modes; an 800-by-600 pixel graphics driver for Windows 2.0 is not provided.

The D1180 uses both the Paradise BIOS and chip set and its performance reflects as much. It is about 50 percent faster than the IBM VGA add-in board; the Compaq and AST boards, which use their own BIOS, are more than twice as fast as the IBM board. Nonetheless, at $445 for the 256KB version, the board is competitively priced.

TATUNG VGA

Tatung, which uses the Video Seven chip set, is moderately compatible with the IBM system-board VGA. Its major advantages, however, are its higher speed and its lower price.

The Tatung VGA board supports only 256KB of RAM and has few extra features. It is XT-height and seven inches long. The back panel contains a 15-pin VGA-type connector; its configuration DIP switches are accessible only with the system cover removed.

Beyond the VGA support, the board has CGA and Hercules emulation. Although the board can be used for EGA and MDA applications, hardware emulation of EGA and MDA is not supported. Extended text modes include 80 characters by 60 lines and 100 characters by 60 lines; graphics extend from 752-by-410 pixels with 16 colors to 640-by-400 pixels with 256 colors.

Software and documentation. The board has a disappointingly small set of software drivers: Lotus 1-2-3 and Symphony, AutoCAD, and Microsoft Windows. To access the extended-mode features, an enhanced video BIOS driver must be loaded. This is an inconvenience and a waste of valuable RAM space; the VGA BIOS on the board should take care of this.

Tatung provides several interesting utilities. CLR clears the entire display, even in extended modes, while the directory listing utility (DU) uses the whole screen to display a directory. A utility called VGA allows setting the board-emulation modes and provides a screen saver. The enhancement selection utility (ESU) sets extended modes. Diagnostic software is supplied.

Detailed installation documentation is provided, including instructions for setting configuration switches on IBM PC and AT system boards. The single 70-page manual is the same size as IBM PC documentation. Technical documentation for the VGA chip set is available separately from Video Seven.

Compatibility and performance. This board has many compatibility problems, including the color 0 failure in mode 11 common to the Compaq, Allstar, and Video Seven boards. The reserved-bits problem in input status register 0 also occurred; the settings are not compatible with either of IBM's methods (system-board VGA or VGA add-in board). The monochrome-mode DAC palette is entirely different than that used by IBM's system-board VGA, even to the point of using bright white for color 255, while IBM uses black. In monochrome mode, the first 36 DAC colors are the same as IBM; after that, all bets are off.

The compatibility test reported more than 50 differences. The board functions correctly with OS/2 1.1, Microsoft Windows/386, and Windows 2.0 in standard VGA modes. The driver provided by Tatung for 800-by-600 pixel, 16-color graphics mode for Windows 2.0 worked correctly when used with a variable-frequency monitor.

The error reported as a difference in the vertical-retrace register shows that the Tatung BIOS locks the CRT controller (CRTC) registers by default; this is not true of IBM. This board does support vertical-retrace interrupts, unlike some of its competitors.

The Tatung VGA is quite fast—almost as fast as the AST and Compaq boards in the text-scrolling tests and twice as fast as the IBM add-in board. It is very economical with a list price of $399 but does have some compatibility problems, particularly its incompatible monochrome-mode palette.

TECMAR VGA/AD

The Tecmar VGA/AD offers a number of features and performance similar to that of the HP D1180A and Paradise VGA Professional. It has several compatibility problems, particularly when used with a monochrome monitor. It can display high-resolution modes on digital displays, rather than requiring a VGA display.

The VGA/AD is larger than many boards; it is XT height and 11.25-inches in length. The VGA chip is by Tseng Labs, while the video BIOS is by Tecmar. The VGA/AD provides both a 15-pin VGA-type monitor connector and a 9-pin digital-display connector. A six-position DIP switch is used to select monitor type and brand, and color or monochrome modes. The board supports the vertical-retrace interrupt.

The VGA/AD has 512KB of RAM and supports text video modes as wide as 132 characters and as high as 60 lines. The graphics resolution goes as high as 1,024-by-768 pixels with 16 colors. Moreover, the board supports all modes on all monitors (except CGA monitors, which are limited in their vertical resolution). Pushing a monitor beyond its physical resolution limits does not always yield good results, and in some cases the board causes an unsteady, interlaced image. Nonetheless, this feature could be valuable when resolution is more important than image quality.

Software and documentation. The Tecmar VGA/AD ships with a significantly extended version of DOS's ANSI.SYS driver. The enhanced driver supports all screen modes available with the VGA/AD, switching among modes, and many of the extended ANSI features not supported by IBM's ANSI.SYS (for example, clear to beginning of line and specification of character height and line length).

Drivers are included for Lotus 1-2-3 and Symphony, Microsoft Windows, AutoCad, FastCAD. GEM, and Ventura Publisher. Instructions for using the VGA/AD with WordPerfect, WordStar, and WordStar Professional are also provided.

Tecmar has been in the add-in board business for a long time, and the packaging of this board shows it. Along with its user manual, Tecmar offers a *Guide to Cover Removal and Replacement*, which covers such arcane information as instructions for removing the cover from the Columbia Data Products PC-compatible computer. The manuals are bound but also are punched for IBM-style binders.

Compatibility and performance. Although the Tecmar video BIOS is flexible, the price of flexibility in this case is speed. The Tecmar board performs the text

scrolling tests 1.5 times faster than the IBM VGA add-in board. This performance is on par with that of the HP and Western Digital boards, but slower than that of the Compaq, AST, Tatung, and Video Seven boards.

The VGA/AD has many incompatibilities with the IBM system-board VGA, but these incompatibilities do not affect the operation of most applications. Tecmar's board shows significant differences between the values in its video BIOS data areas and IBM's video BIOS data areas. The values, however, accurately indicate the state of the VGA/AD; a programmer who codes to IBM's documentation should be able to read Tecmar's video data areas without much difficulty.

Reserved bits in the VGA/AD input status register 0 differ from IBM's reserved bits (both system and add-in boards). In addition, a reserved bit is set in the feature control register. Tecmar also uses different values for the CRTC registers; this presents a potential synchronization problem on some monitors. Finally, the cursor emulation on the VGA/AD is inaccurate.

The Tecmar board is the only one reviewed that requires a switch to change to monochrome mode when using a monochrome monitor. Compatibility in monochrome mode is a problem, most notably in the registers and the data areas. DAC palette register settings were wrong from color 1 on. The VGA compatibility test gave up after finding 50 differences.

The VGA/AD functions correctly with OS/2 1.1, but has some problems with Windows/386 in standard VGA modes in that it fails to reload the proper font when switching among applications. It operates correctly with Windows 2.0 in standard mode, and in 800-by-600 pixel graphics mode, using the driver provided.

This board is appropriate for those who can use the extended video modes or who need a variety of video modes on a single monitor. Its flexibility is its strong point, but anyone expecting to use a monochrome monitor should look elsewhere.

VIDEO SEVEN V-RAM VGA

Video Seven's stated goal for its V-RAM VGA is to emulate exactly IBM's add-in board for PCs, while improving speed. It has mostly succeeded in the first and succeeded very well indeed in the second objective. The V-RAM VGA is the same full-length, two-thirds height as the IBM PS/2 Display Adapter and has the same connectors in the same positions (although it adds the 16-bit interface). It is physically compatible with any products designed to fit the IBM board. Like Western Digital Imaging with its Paradise chip set, Video Seven makes and uses its own chip set.

The V-RAM VGA is the only board reviewed that comes with a lifetime guarantee of compatibility with IBM's PS/2 Display Adapter. The guarantee states that if the V-RAM VGA fails to operate properly in a situation where IBM's board does, Video Seven will either fix the problem or refund the purchase price. This is not the same as guaranteeing compatibility with the IBM system-board VGA, because even IBM's PS/2 Display Adapter is not 100-percent compatible with it.

The V-RAM board comes with 256KB of RAM; additional memory can be added, but the board uses ZIP-pack chips which are less common than the usual DIP packages. Video Seven sells its own memory-upgrade kit. In addition, a V-RAM VGA appendix lists parts numbers for this type of RAM available from other vendors.

The board supports six enhanced text video modes beyond what IBM's system-board VGA supports. The widest enhanced text video mode is 132 characters and the highest is 60 lines. In addition, graphics resolutions as high as 1,024-by-768 pixels with 16 colors are available.

The utility software supplied with the board is basically the same as that which comes with the Tatung board, except that the ESU works without having to install the RAM BIOS. ESU displays all possible video modes (based on the monitor in use) and allows the user to select among them. The included version of the ANSI.SYS driver supports whatever screen size is selected this way.

To improve compatibility with IBM's system-board VGA, the V-RAM VGA board supports vertical-retrace interrupts. This feature is enabled and disabled with a jumper.

The VRAM VGA works fine with OS/2 1.1 and Microsoft Windows/386 and Windows 2.0 in VGA mode. It also works correctly with Windows 2.0 in 800-by-600 pixel mode. It and the Tatung VGA are the only boards reviewed that provide a Windows/386 driver for this enhanced graphics mode.

Software and documentation. Video Seven supports AutoCAD, Lotus products, Ventura Publisher, Microsoft Windows, WordPerfect, and WordStar. The bound manuals provided are complete and well illustrated.

Compatibility and performance. Despite its guarantee of compatibility, the V-RAM VGA has several compatibility problems, most of them the same ones encountered by the Tatung board, which uses the same chip set. The DAC errors are the same, as is the writing failure in mode 11. Video Seven has no problem with the reserved bits in input status register 0. Like the Tatung board, the palette in monochrome mode is wrong, and screen appearance suffers because of it. Except for the monochrome mode problems, these incompatibilities are not likely to affect the operation of most applications.

Like the Tatung VGA, this board is twice as fast as the IBM VGA add-in board in the text- and window-scrolling tests, following closely behind the Compaq and AST boards. With its high-speed video RAM, it has the fastest graphics of all the boards reviewed.

WESTERN DIGITAL PARADISE VGA PROFESSIONAL

The Paradise VGA Professional from Western Digital Imaging is one of the most compatible of the boards reviewed; its price, however, is among the highest ($799). Using a newer version of the same chip set and the Paradise ROM BIOS used by Hewlett-Packard, this board supports all standard VGA modes, emulates the EGA, CGA, MDA, and Hercules boards, and provides the same eight advanced modes as the AST and HP boards. The Paradise VGA Professional comes standard with 512KB of RAM in order to support these extra modes.

The back panel holds a single VGA-type 15-pin connector and an opening through which a four-position DIP switch can be set. The switch is used to set monitor type (VGA or multifrequency) and 8-bit or autosense 16-bit operation.

The board supports 8- or 16-bit data bus transfers and also can use the video BIOS in a 16-bit mode. The board performs a test at boot time to sense whether the 16-bit mode is usable. The user can manually specify 8-bit or 16-bit modes by setting a jumper on the board.

Like the AST VGA, which incorporates the Paradise chip set, using 16-bit mode requires that the entire memory map from address C0000H to DFFFFH be empty (which excludes most hard-disk drives, expanded-memory boards, and network boards). The board worked fine, however, in the AT test machine and in a machine that had boards with the ROM BIOS in this address range.

Software and documentation. The Paradise VGA Professional comes with device drivers to support AutoCAD, GEM, CADVANCE, Ventura Publisher, Microsoft Windows, and Framework II. It also has instructions for using extended text modes with WordPerfect and WordStar.

The board comes with two manuals. A user's guide describes installation of the board and operation of its utilities, and a software manual describes device drivers that come standard with it. A file on the second utility diskette gives information on programming advanced video modes.

Compatibility and performance. During its three-year warranty period, Western Digital guarantees that the VGA Professional will run any software that the IBM VGA add-in board will when installed in an IBM PC/XT or PC/AT. The Paradise VGA Professional fared better in the VGA compatibility tests than the AST and HP boards, which also use the Paradise chip set. The only failures detected were the different status of the reserved bits in input status register 0, the lack of vertical-interrupt support, a problem with cursor positioning, and visibly jerky scrolling on the horizontal pan test. All of these, except the latter, are also problems of the IBM add-in VGA board. The problems encountered with this board are mainly cosmetic and not likely to affect applications. Like the AST and Hewlett-Packard boards, it causes a blank screen when changing to an emulation mode if the mouse driver is loaded.

The VGA Professional works fine with OS/2 1.1, Microsoft Windows/386, and Windows 2.0 at standard VGA resolutions. It also works with Windows 2.0 in 800-by-600 pixel graphics mode. The VGA Professional offers almost identical performance to the Hewlett-Packard D1180, but is not as fast as the Compaq and AST boards, with their optimized ROM BIOS.

Those who find the VGA Professional expensive at $799 may want to consider the Paradise VGA Plus 16, which is identical to the VGA Professional except that it provides only 256KB of memory and costs $499.

THE RIGHT FIT

In choosing a VGA, many people will care more about VGA speed than compatibility, and most VGA board manufacturers are banking on that fact. All the boards reviewed here, with their 16-bit interfaces, provide better performance than the IBM add-in board at the expense of some compatibility.

For text speed, the highly compatible Compaq VGC (reviewed in November) takes highest honors. It uses a Paradise chip set and, by taking care with the video BIOS, achieves significantly better text performance than any other board, including those using the same chips, even Paradise. Its major disadvantage is lack of support for any extended graphics modes.

Video Seven and Western Digital provide high resolution as well as compatibility with IBM's system-board VGA and guarantee that their boards can run any application in the same way that IBM's does. This combination is expensive, at $200 and $300 more, respectively, than their nearest competitors. AST and Hewlett-Packard offer good boards for the price, and AST's is almost as fast as Compaq's. The Tatung VGA is a bargain if you can live with its incompatibilities. (Note, however, that many of these boards are heavily discounted, so prices may vary.)

In graphics mode, the boards all perform about the same. The VRAM VGA with its V-RAM display buffer is slightly faster than the others. Note that the graphics test used incorporates C-library routines that do not take advantage of the 16-bit data interface provided on these boards. As 16-bit graphics routines become available, all of these boards will show much better graphics performance than 8-bit VGAs.

Video Seven offers the widest array of supported modes, high resolution, good speed, and excellent compatibility—but for the highest price by far. If operation in monochrome mode is necessary, however, stay away from both the Tatung and Video Seven boards. These have unacceptable failures in monochrome mode.

Although the VGA is a relatively new product, the market for it has rapidly matured. All of the boards reviewed will run properly in the majority of situations. Boards with 16-bit interfaces provide higher performance than 8-bit VGAs, often at little additional cost. The enhanced graphics these boards provide when used with high-resolution monitors can be used with DOS now, and with OS/2 when video drivers become available.

The vendors here, with the exception of Tatung, are working to make these drivers available in the near future. Among them, many trade-offs exist in speed, compatibility, features, and price, but every buyer should be able to find a comfortable fit.

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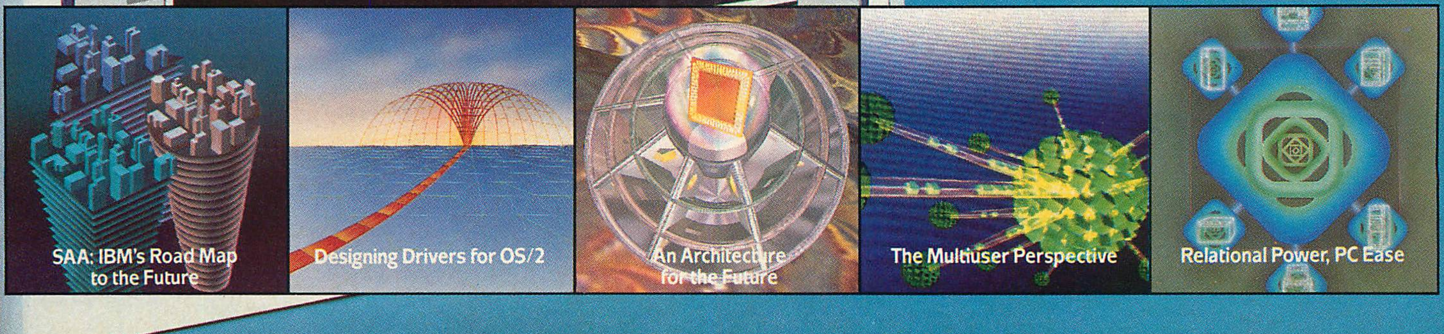

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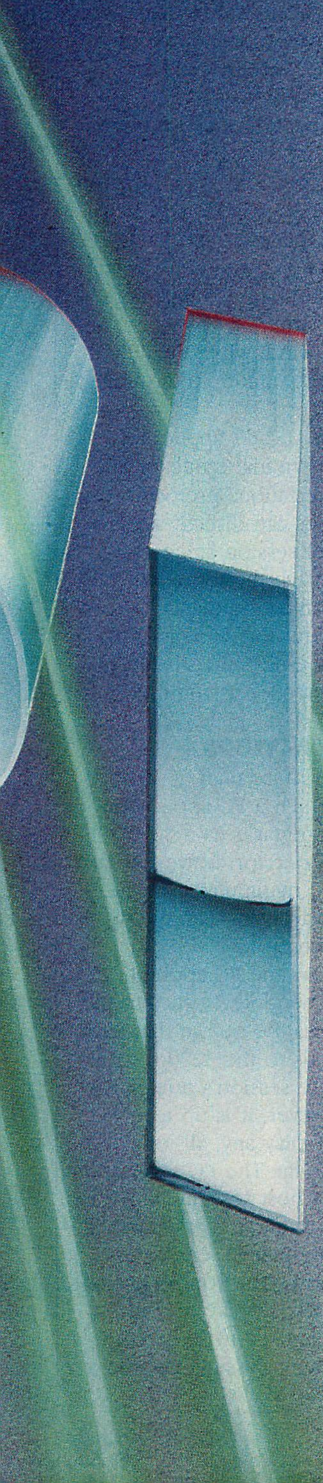


The High Road to Host Connectivity

The HLLAPI route to host connectivity capitalizes on the PC's approachable interface, while maintaining transparent exchange with the host.

MICHAEL TRINER

Not long into the high-flying, early days of microcomputers, developers' level of excitement mounted even higher as they began to realize the communications potential of these new desktop wonders. Those who were still semiregular members of the mainframe faithful fairly glowed at the thought of marrying the versatility and independence of the PC with the power and capacity of the mainframe. Thus was born "host connectivity."

The inherent challenge to such a liaison is that microcomputer users quickly grow accustomed to a machine that is versatile and independent and, perhaps most importantly, personal. Their tolerance for the mainframe's obtuse interface is understandably low, and emulation packages take you only so far—they make the PC act like a dedicated terminal. Early on, the situation cried out for a better solution.

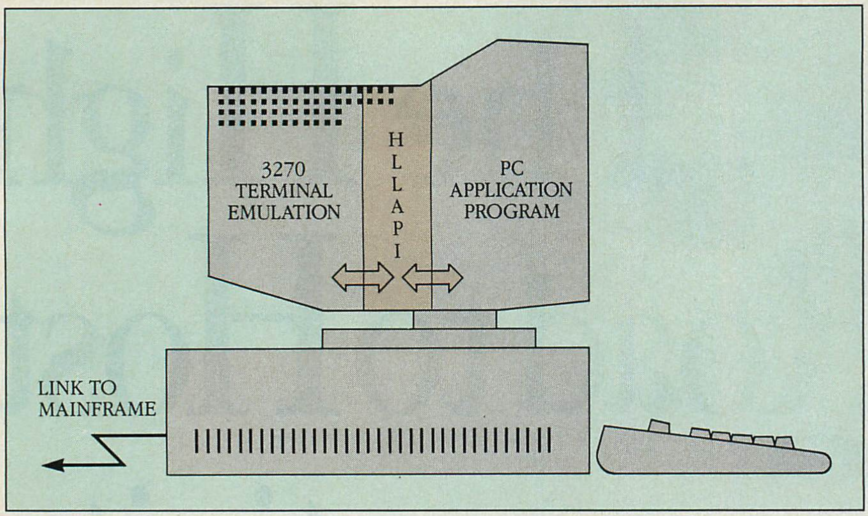
IBM's 1986 response—the High-level Language Application Program Interface (HLLAPI)—is a start. HLLAPI allows PC application programs to work with IBM 3270 terminal emulators to manipulate tasks and transfer data, while shielding the user from the rigid data formats and cryptic messages associated with many mainframe applications (see figure 1). Significantly, HLLAPI provides a standard interface that is not limited to a particular terminal emulator.

IBM offers HLLAPI support for the 3270 Workstation Program (which replaces the IBM 3270-PC Control Program) and a subset of HLLAPI called Entry Emulator HLLAPI (EEHLLAPI) for use with its entry-level 3270 Emulation Program. IBM also plans EEHLLAPI support in a future release of the OS/2 Extended Edition Communications Manager (although not 1.0 or 1.1).

Moreover, HLLAPI support is not limited to IBM terminal-emulation software. Attachmate and Digital Communications Associates (DCA) also offer

ILLUSTRATION • PAUL NEWMAN

FIGURE 1: *How HLLAPI Buffers the User*



HLLAPI, in cooperation with the PC application, acts as a bridge between the PC user and the mainframe application. Using HLLAPI, the PC application carries on a complex dialog with the mainframe but displays only relevant data to the user.

IBM-compatible HLLAPI interfaces for their respective 3270 terminal-emulation products, EXTRA! and IRMALAN SNA Workstation.

HLLAPI is one of several routes available to enable a program running on the PC to automate and simplify the PC user's mainframe interaction. These methods are divided into two broad categories: those that require execution of a program only on the PC, and those that require programs to be written for the mainframe and the PC.

HLLAPI falls into the first category. It works in conjunction with 3270 terminal emulation software to support simplified host connectivity without any changes to mainframe software. Methods in the second category, on the other hand, provide more generalized data transfer and support, but require host software development. IBM's advanced program-to-program communications (APPC) and enhanced connectivity facilities/server requester programming interface (ECF/SRPI) are examples of the second category. Both require extensive host programming (see "Connectivity Pathways: APPC or NETBIOS," Michael Hurwicz, November 1987, p. 156).

APPC provides communications among cooperating programs in a network; the programs can be running on microcomputers, minicomputers, or mainframes. Programs exchanging information run in nodes on the network using an IBM Systems Network Architecture (SNA) protocol for peer-to-peer communications between network logical units (LU 6.2).

ECF/SRPI affords a consistent interface for PCs to use in accessing mainframe resources and exchanging data. Requester programs running on the PC request and receive data and services from programs running on mainframe hosts equipped with Multiple Virtual Storage/Extended Architecture (MVS/XA) and Virtual Machine/System Product (VM/SP). ECF/SRPI allows programmers to develop shared data applications that are isolated from the underlying communications protocols used to transfer shared data.

Because APPC and ECF/SRPI require host programming, they are better suited to new application development. Simplified access to existing mainframe applications requires PC programs that manipulate the 3270 data stream without the cooperation or knowledge of the host application.

The most direct (and tedious) way for a program to manipulate the host data stream is to access the 3270 terminal emulation or use its low-level API. This method can yield good performance and requires little memory overhead; however, such applications generally must be in assembly language, and programs written for a particular terminal emulator will not work with another terminal emulator.

THE HIGH ROAD

For many, HLLAPI is more convenient than APPC and ECF/SRPI for supporting simplified communications between the PC user and a host application. HLLAPI applications are not difficult to develop and require no changes to host programs; they perform terminal operator functions using a simple set of function calls (see table 1). Applications can be written in a high-level language, rather than the assembly-language coding required when using low-level APIs. They are not limited to a single terminal emulation product.

Programs that use HLLAPI handle an assortment of tasks, from simple automatic host logon to the complexities of starting and monitoring an unattended host task. Developers can customize PC screens to display only necessary fields from a host screen or to perform error checking prior to porting data to a host application. The PC application can locally validate and augment data sent to the host application, saving expensive machine time and storage space on the host.

The developer can make a single screen out of what would be many screens on the host. The PC application can use multiple sessions to run more than one host application simultaneously and display selected fields from each of the sessions on a single composite screen for the user to view. HLLAPI permits windowing, thus eliminating the need for multiple terminals on a user's desk.

Because the HLLAPI application works with the terminal emulator and existing communications protocols, the developer or user can directly access the host terminal session as necessary. The ability to switch the terminal-emulation session to the display screen can be quite useful for debugging applications or for times when extensive ad hoc host interaction is required.

STEP UP TO FUNCTIONS

HLLAPI provides more than 30 functions through which a PC application performs the same tasks as a 3270-series terminal operator; however, data are received and manipulated in the PC's memory and not necessarily displayed on the screen.

HLLAPI allows the PC application to generate and send keystrokes to the host and to access the output that each host session sends to the 3270 display screen (called the session's *presentation space*); however, it is up to the application to display any, all, or none of the received data. The PC application can connect to a host session (function 1), set the session parameters (function 9) shown in table 2, and send keystrokes to the host (function 3) to sign on and request the display of data.

Function 6 is used to search the presentation space to assure that the

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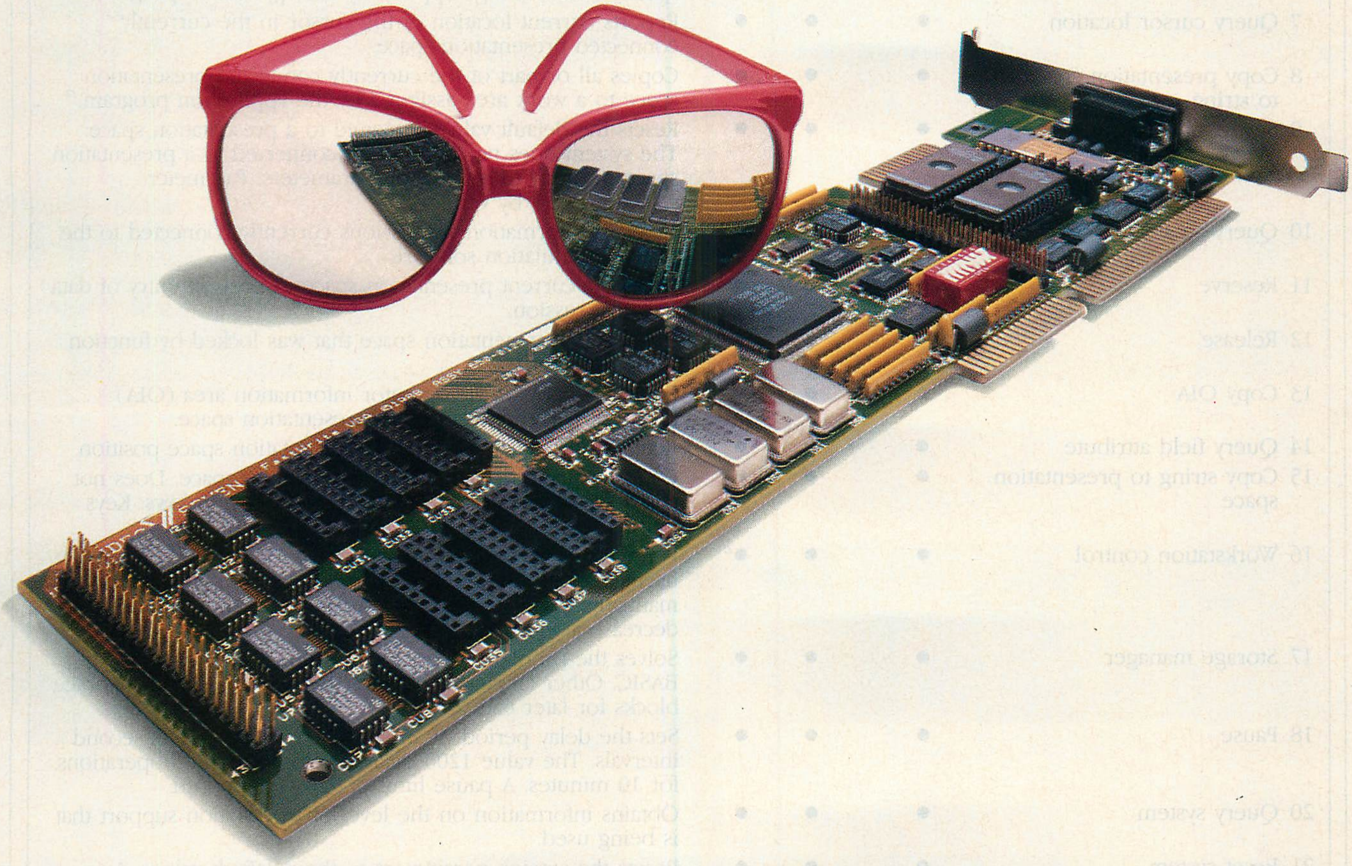

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TABLE 1: *HLLAPI Commands*

FUNCTION CODE AND NAME	ATTACH-MATE	DCA	IBM	ACTION
0 Attachmate query system	●	○	○	Reports the version of Attachmate software installed and the type of connection.
1 Connect presentation space	●	●	●	Connects to a specified presentation space. This function must complete successfully for most other functions to work. Only one presentation space may be connected at a time.
2 Disconnect presentation space	●	●	●	Disconnects from the current presentation space.
3 Send key	●	●	●	Sends string of keystrokes to most recently connected presentation space just as an operator would have typed it.
4 Wait	●	●	●	Waits approximately one minute before returning the status of the presentation space. Driven by the XCLOCK and XSYSTEM indicators.
5 Copy presentation space	●	●	●	Copies the currently connected presentation space into a work area assigned by the application program.
6 Search presentation space	●	●	●	Searches the presentation space for the first occurrence of a specified data string supplied by the application program.
7 Query cursor location	●	●	●	Reports current location of the cursor in the currently connected presentation space.
8 Copy presentation space to string	●	●	●	Copies all or part of the currently connected presentation space to a work area assigned by the application program.[a]
9 Set session parameters	●	●	●	Resets the default values assigned to a presentation space. The system does not need to be connected to a presentation space in order to set session parameters. Parameter selections vary by vendor.[b]
10 Query sessions	●	●	●	Provides information on sessions currently connected to the terminal emulation software.
11 Reserve	●	●	●	Locks the current presentation space to prevent entry of data into that session.
12 Release	●	●	●	Unlocks the presentation space that was locked by function code 11 (reserve).
13 Copy OIA	●	●	●	Returns a copy of the operator information area (OIA) from the currently connected presentation space.
14 Query field attribute	●	●	●	Returns field attribute byte for presentation space position.
15 Copy string to presentation space	●	●	●	Copies a string of data to the presentation space. Does not copy key codes, such as clear, PA1, or function keys. Keys must be sent through function code 3 (send key).
16 Workstation control	●	●	●[c]	Permits use of workstation control functions without actually having to call the keystrokes needed to do the operation manually. Performs functions such as add, move, enlarge, or decrease a window.
17 Storage manager	●	●	●	Solves the problem of storage allocation when writing in BASIC. Other languages can use this for setting aside storage blocks for later use.
18 Pause	●	●	●	Sets the delay period of an HLLAPI program in half-second intervals. The value 1200 delays the programmed operations for 10 minutes. A pause limit of 7200 is imposed.
20 Query system	●	●	●	Obtains information on the level of workstation support that is being used.
21 Reset system	●	●	●	Resets the session parameters to their default values. Any reserved presentation spaces are released. Any connected presentation space is disconnected. Any alternate presentation spaces are disconnected and deleted.
22 Query session status	●	●	●	Provides more detailed information on the session. Information includes the long and short names, the session type, session characteristics, and the number of rows and columns in the presentation space.
23 Start host notification	●	●	●	Notifies the application program if the presentation space, host system OIA, or both have been updated. This function also ends a pause started with function code 18 (pause).
24 Query host update	●	●	●	Allows the programmed operator to determine if the host system has updated the OIA, presentation space, or both since the last time this request was made. Function code 23 (start host notification) must be completed prior to executing this particular function.

FUNCTION CODE AND NAME	ATTACH-MATE	DCA	IBM	ACTION
25 Stop host notification	●	●	●	Stops the host notification process. Also stops host events from affecting function code 18 (pause).
30 Search field	●	●	●	Examines a field within the currently connected presentation space for the occurrence of a data string defined by the application program.
31 Find field position	●	●	●	Returns the beginning position of a selected field in the currently connected presentation space. Searches for both protected and unprotected fields.
32 Find field length	●	●	●	Returns the length of a specified field. The field must be located in a host presentation space.
33 Copy string to field	●	●	●	Copies a string of data into a specified field in the currently connected presentation space.
34 Copy field to string	●	●	●	Copies data from a specified field in the currently connected presentation space to a user-defined work area. The copy will continue until the work area has been exceeded, or the end of the field or presentation space is reached.
35 Define presentation space	○	○	●[c]	Creates an alternate presentation space. Used only for multi-DOS workstation setup; not to be used with interpreted or compiled BASIC.
36 Switch presentation space	○	○	●[c]	Switches between the base presentation space and the presentation space that is defined using function code 35 (define presentation space). Not to be used with interpreted or compiled BASIC.
37 Display cursor	○	○	●[c]	Lets the application program display the cursor in a specified area of the presentation space or the alternate presentation space. Not to be used with interpreted or compiled BASIC.
38 Display presentation space	○	○	●[c]	Redraws the presentation space created by function code 35 (define presentation space). Not to be used with interpreted and compiled BASIC.
39 Delete presentation space	○	○	●[c]	Deletes the alternate presentation space defined using function code 35 (define presentation space).
50 Start keystroke intercept	○	○	●[c]	Lets the application program accept and filter any keystrokes entered by the terminal operator.
51 Get key	●	○	●[c]	Lets the application program receive host session keystrokes. Function code 50 (start keystroke intercept) must have been specified prior to the use of this function.
52 Post interrupt status	●	○	●[c]	Notifies the operator if the keystroke obtained through function code 51 (get key) was accepted or rejected. Rejected keystrokes are signified by a beep.
53 Stop keystroke intercept	●	○	●[c]	Stops the interception of keystrokes started with function code 50 (start keystroke intercept).
90 Send file[d]	●	●	●	Sends a file from the PC session where HLLAPI is running to a host session.
91 Receive file[d]	●	●	●	Permits a machine running HLLAPI to receive from the host a file transferred into the PC session running HLLAPI.
92 Invoke DOS program[d]	●	●	●[c]	Invokes a subprocess application program without terminating the current application program.
93 DOS redirect[d]	●	●	●[c]	Executes any DOS command including the loading and running of programs from within an HLLAPI program.
99 Convert position on RowCol	●	●	●	Changes the presentation space position into a PC display, row-column format; or changes the PC row-column format to a presentation position. Does not change cursor position.
255 DCA query	○	●	○	Returns information specific about the emulator environment, such as type of emulator, emulator version numbers (both major and minor), keyboard type, printer type, short name of emulator, zoom mode status, and country code.

● = *Yes* ○ = *No*

[a] *The upper-left position of the presentation space is number 1 and the bottom-right position is the maximum screen size number. The maximum screen size is limited to the type of terminal being emulated: 1,920 for Model 2; 2,560 for Model 3; 3,440 for Model 4; and 3,564 for Model 5.*

[b] *See table 3 for a list.*

[c] *Functions 16, 35 through 39, 50 through 53, 92, and 93 are not supported by EEHLLAPI.*

[d] *To use functions 90 through 93, an application must release all unused memory and assign a block of memory using the DOS SETBLOCK function. Failure to allocate memory will result in abnormal termination of these functions.*

Although all three packages are solid HLLAPI implementations, IBM's 3270-PC HLLAPI 3.1 includes several functions that the others do not—such as intercepting keystrokes entered to the host session and supporting an alternate presentation space.

TABLE 2: *Session Parameters*

SESSION PARAMETER	EFFECT
ATTRB	Returns attributes as hexadecimal numbers.
NOATTRB[a]	Returns attributes as blanks.
CONPHYS[a]	Causes a physical jump to the session.
CONLOG[a]	Makes only a logical connection.
EAB	Copies both data and extended attribute bytes when copying the presentation space to a string. Copies two characters from the presentation space for every one that appears on the screen that will be copied.
NOEAB[a]	Does not use EABs. Passes data only.
ESC=*n*	Specifies the escape character to be used. (The @ symbol is the default escape character.)
EOT=*n*	Specifies end of string character. (A binary zero is the default end of string.)
FPAUSE[a]	Uses a full-duration pause.
IPAUSE	Uses an interruptible pause. Function code 23 (start host notification) will satisfy a function code 18 (pause).
STRLEN[a]	Uses explicit length strings.
STREOT	Uses strings terminated by the code specified by the EOT command.
SRCHALL[a]	Searches the entire presentation space.
SRCHFROM	Searches from the user-supplied offset.
SRCHFRWD[a]	Searches from position 1 of presentation space.
SRCHBKWD	Searches from last position to start of presentation space.
TWAIT[a]	Waits a specified amount of time for keyboard to become ready before returning to the application program.
LWAIT	Waits until keyboard is ready before returning to the application program.
NWAIT	Returns immediately to the application program with status of keyboard.
TRON	Turns trace function on.
TROFF[a]	Turns trace function off.
AUTORESET[a]	Sends a reset key to emulator prior to the use of function code 3 (send key).
NORESET	Does not send the reset key before function code 3 (send key).
QUIET	Inhibits the display of messages via the INT 21H, AH=9 function from being displayed.
NOQUIET[a]	Allows normal flow of messages to be displayed.
TIMEOUT=*n*	Lets HLLAPI know how many 30-second cycles to elapse before sending a Ctrl-Break sequence.
TIMEOUT=0[a,b]	Displays time-out messages every 30 seconds until the operator depresses Ctrl-Break.
XLATE	Translates EABs.
NOXLATE[a,b]	Does not translate EABs.
NEWRET[a,c]	Uses IBM HLLAPI version 3.0 return code conventions.
OLDRET[c]	Uses IBM HLLAPI versions 2.0 return code conventions.

Except where noted, session parameters are supported by IBM, Attachmate, and DCA.
[a] *Default value of the parameter when the session is started.*
[b] *Supported by IBM only.*
[c] *Supported by Attachmate and DCA only.*

These session parameters, which are set using function 9 (set session parameters), specify the conventions and options to be used for interaction with HLLAPI.

host has displayed the requested screen, and function 5 copies the presentation space to a program work area. From there, the application's screen-handler routine can display all or part of the data received from the host. This is the basic flow of an HLLAPI application program.

Because of disparities between the PC and 3270 terminal keyboards, the application must translate certain user-entered characters before passing them along to HLLAPI. Although alphanumeric keys require no translation, a translation table is necessary to support the transmission of 3270 terminal keystrokes for which there is no PC keyboard equivalent. Terminal keys such as program function (PF) keys are represented using mnemonics made up of multiple ASCII characters. Table 3 lists key formats that IBM, Attachmate, and DCA use; additional mnemonics are available for functions such as system request, erase input, and device cancel.

Function 3 (send key) delivers the values listed in the table to the presentation space. Function code 15 (copy string to presentation space) copies only characters that do not have a special mnemonic value, such as alphanumeric characters and punctuation.

To send a PF1 key to the host through HLLAPI, the application uses function 3 to transmit an **@1** (with a trailing binary zero if STREOT was selected when the HLLAPI system parameters were set using function 9; otherwise, a string length of 2 is specified in the function call). Table 2 lists the parameters that can be specified for the HLLAPI session. This process works the same for all mnemonics in table 3.

For performance reasons, function 15 (copy string to presentation space) should be used when transmitting a string that is more than a few characters long. The speed difference between using function 3 and function 15 is dramatic when moving screens of data without control characters (such as PF keys). Function 15 does not transmit PF keys, program attention (PA) keys, or cursor-command keys; these must be sent through function 3. This does not seriously impact the system, largely because it is uncommon to send many PF keys at once. When copying data from the presentation space to a string, use function 8 (copy presentation space to string).

OUT ON A LIM

A PC application program initiates a function, such as sending a series of keystrokes to the mainframe, by calling the HLLAPI language interface module (LIM) bound into the executable version of the application program. The LIM is a bridge between the PC application program and the memory-resident HLLAPI.EXE module. Figure 2 diagrams the process by which an HLLAPI function is executed; the LIM accomplishes the following:

- Accepts calls for HLLAPI services
- Builds a parameter control block (PCB) using parameters passed from the application
- Converts any language data format to the HLLAPI standard
- Calls HLLAPI.EXE using INT 7FH

HLLAPI.EXE is a memory-resident program that receives and interprets requests from the LIM, then passes them along to the emulation program, which performs the requested task. When the task is complete, HLLAPI.EXE returns control to the LIM, which in turn returns control and any values received to the application program.

Attachmate and DCA provide LIMs for popular programming languages—Microsoft C, COBOL, BASIC (interpreted and compiled), Pascal, Lattice C, and Borland's Turbo Pascal; IBM offers LIMs only for its versions of BASIC, C, COBOL, and Pascal. All three vendors direct the programmer in creating a LIM for languages in which they do not supply LIMs. Assembly language programs can access HLLAPI.EXE without using a LIM.

The following two examples (for Pascal and COBOL) demonstrate the programming requirements and the process for linking the application program to the compatible LIM. For Pascal, declare the following variables:

```
VAR Fun_code, Length, Ret_Code :Integer;
Data_string :String;
PROCEDURE HLLPAS (VAR Fun_code:
  Integer;
VAR Data_string: String;
VAR Length, Ret_Code :Integer);Extrn;
```

To initiate an HLLAPI function from within the application program, use the statement

```
HLLPAS (Fun_code, Data_string,
  Length, Ret-Code);
```

Fun_code, which is always required, specifies the number of the HLLAPI command to be executed. It always returns unchanged. **Data_string** contains information to be transferred between the application and the HLLAPI resident interface module.

Some HLLAPI functions require that **data_string** contain many different fields either to pass multiple text fields to HLLAPI or to retrieve multiple fields once a function has executed. Some Pascal implementations do not allow explicit substring functions for string variables. Defining **data_string** as a variant record is a workaround to this limitation.

Length specifies the length of the data string to be passed to HLLAPI. Certain commands return a presentation space position in this variable. **Ret_Code** contains a code to indicate the success or failure of the requested command. For some commands, this parameter is used to pass a presentation space position to HLLAPI.

TABLE 3: *Mnemonics*

KEY	MNEMONIC
Backtab	@B
Clear	@C
Delete	@D
Enter	@E
Erase EOF	@F
Insert	@I
Cursor left	@L
New line	@N
Print	@P
Reset	@R
Tab	@T
Cursor up	@U
Cursor down	@V
Cursor right	@Z
Home	@0
PF1	@1
PF2	@2
PF3	@3
PF4	@4
PF5	@5
PF6	@6
PF7	@7
PF8	@8
PF9	@9
PF10	@a
PF11	@b
PF12	@c
PF13	@d
PF14	@e
PF15	@f
PF16	@g
PF17	@h
PF18	@i
PF19	@j
PF20	@k
PF21	@l
PF22	@m
PF23	@n
PF24	@o
PA1	@x
PA2	@y

Special 3270 terminal keys are represented using ASCII characters. The codes are case-sensitive: @C for the Clear key, but @c for the PF12 key.

The Pascal LIM is linked to the application program by first compiling the Pascal program, then linking in the LIM using the command

```
LINK PASAPP+HLLPAS
```

where PASAPP is the name of the compiled Pascal application .OBJ file, and HLLPAS is the Pascal LIM .OBJ file provided with HLLAPI. The application can be run once the emulation program and HLLAPI.EXE are loaded.

For COBOL, declare the following HLLAPI variables in DATA DIVISION:

```
77 FUNCODE    PIC 99  COMP-0.
77 RETCODE    PIC 99  COMP-0.
77 STRLEN     PIC 99  COMP-0.
01 DATA-STRING  PIC X(1920) VALUE
    SPACES.
```

Use the following code to call the LIM from the HLLAPI application program:

```
CALL 'COBLIM' USING FUNCODE DATA-
  STRING STRLEN RETCODE.
```

The above names can be altered to fit individual naming conventions. Be sure that the data-string size is large enough to contain the maximum-size presentation space specified. A COBOL HLLAPI application is linked in the same way as its Pascal counterpart, except that HLLCOB is the name of the LIM .OBJ file specified in the link command.

DELIVERING DATA

The parameter control block (PCB) transfers data between the application and HLLAPI.EXE. The LIM generates PCBs from the application's function requests. Assembly language programs, which access HLLAPI.EXE directly, must create their own PCBs. IBM, Attachmate, and DCA all use the same PCB layout:

```
PCB_header    db 'PCB'  ; constant value
PCB_function  db 0      ; function number
PCB_data_seg  dw 0      ; segment address
PCB_str_adr   dw 0      ; offset address
PCB_length    dw 0      ; string length
PCB_filler    db 0      ; unused
PCB_retcode   dw 0      ; return code
PCB_str_len   dw 25000  ; max size
```

PCB must be present in uppercase letters as the first three characters of the control block. PCB_function must be the one-byte binary function code. PCB_data_seg and PCB_str_adr represent the segment address and the offset of the data string, in that order. PCB_str_adr must point to the actual string and not to a length or pointer prefix. Depending on the function called, the data string contains such items as the presentation space ID or a value used in the search presentation space function.

PCB_length should be the actual string length, in bytes, of the value passed to the HLLAPI module. This value is not used when function 9 is executed with the parameters STREOT (string lengths not explicitly coded) and EOT=n (where n is the character that signals end of transmission). This allows HLLAPI to accommodate both counted strings, as in Turbo Pascal, and

zero-terminated strings, as in C. PCB_length contains the actual length of the string if the chosen language, BASIC for example, provides a length value. If the language does not do so, HLLAPI imposes a default length of 25,000 bytes.

Not all functions use all areas of the PCB; some use areas to hold returned data values available after HLLAPI returns control to the application program. The return code is passed directly back to PCB_retcode. HLLAPI passes data strings directly back to the string area specified in the PCB_str_adr.

When writing an assembly language program to access the HLLAPI.EXE module directly, include the PCB setup in the data area of the program and set the appropriate addresses in the PCB. Executing an INT 7FH calls HLLAPI.EXE into action to process the requested function.

HLLAPI ACTION

The first step in developing an HLLAPI application is to analyze every step performed at the keyboard to accomplish the task to be automated. This could be signing on, accessing a system selection menu, using a host application, or all three. Then, break the process into logical tasks: sign-ons and possible errors in one task, system transactions and possible errors in another, sign-offs and possible errors in a third.

Planning for many contingencies is a must in designing an HLLAPI application. The application must be prepared to handle all responses from the host, including ones that result when the host application receives incorrect or improperly formatted data. In addition, host responses can come from sources other than the host application: notification messages from TSO, queued-up messages from Information Management System/Data Communication (IMS/DC), messages from other users, and the dreaded "System going down in 10 minutes" messages from the system operator (for details on host-3270 connection contingencies, see "Exploiting the 3270 Connection," Mary DeWolf, July 1987, p. 94). The application should be designed to ignore messages known to be inconsequential to the user and to pass along all unidentifiable messages.

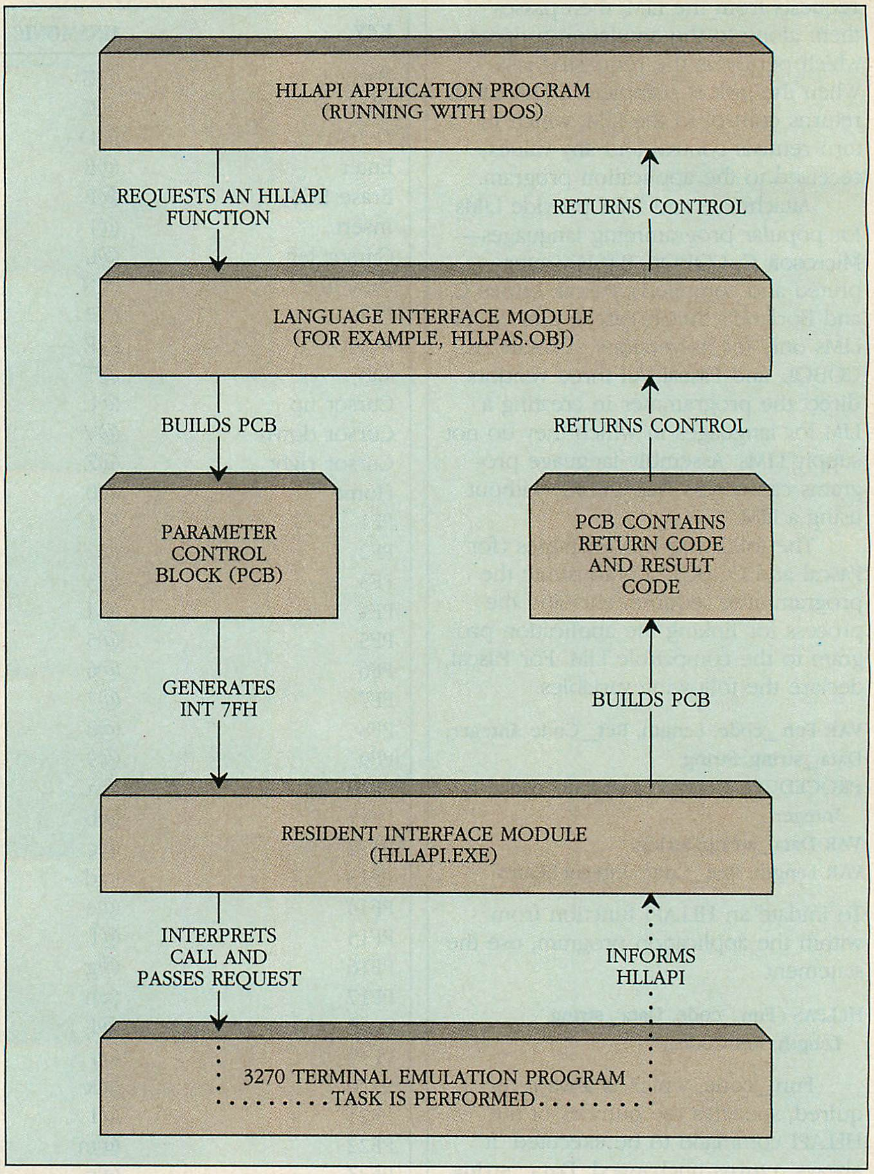
The sample Pascal HLLAPI application shown in figure 3 logs onto the mainframe system and copies a screen of data into the HLLAPI application work area. Before the actual logon takes place, the application first sets session parameters using function 9 and connects to the presentation space using HLLAPI function 1.

If the session connection is successful, the application uses function 6 (search presentation space) to search the presentation space for a host-system-specific string (in this example, DIALED TO PRODDOS), which indicates that the system is available to accept a sign-on. The application then uses function 15 to copy the sign-on string to the presentation space and function 3 to send an Enter key command to the host.

Function 4 (wait) returns control to the application when the host has responded to the sign-on request, and function 6 searches the presentation space for the string (in this example, VM/PRODUCTION LINE) that indicates a successful sign-on. The application then uses function 8 to copy the contents of the presentation space into **data_string** for additional processing.

With the sign-on successfully completed, the application is ready to accept requests from the user and then use HLLAPI functions to pass them along to the host mainframe. As host responses are received, the application uses HLLAPI to retrieve data from the presentation space and displays it for the user.

FIGURE 2: ***The HLLAPI Process***



A high-level language PC application initiates 3270 terminal functions by calling the language interface module (LIM) that is linked into the executable version of the application program. Following appropriate translation, the request is passed through HLLAPI.EXE to the terminal-emulation program for action.

FIGURE 3: *A Sample Application*

SET SESSION PARAMETERS

```
FUN_CODE := 9 ;                 {API FUNCTION NUMBER}
RET_CODE := 0 ;                 {SET RETURN CODE TO ZERO}
COPYSTR('STREOT,NWAIT',DATA_STRING) ; {PARAMETERS TO SET}
LENGTH := 12  ;                 {LENGTH OF PARAMETER STRING}

HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE ) ;
IF RET_CODE <> 0
   THEN BEGIN
   WRITELN ( 'ERROR 001: SET PARAMETERS FAILED' ) ;
   END ;
```

CONNECT TO SESSION

```
FUN_CODE := 1 ;                 {API FUNCTION NUMBER}
RET_CODE := 0 ;                 {SET RETURN CODE ZERO}
COPYSTR('E',DATA_STRING) ;      {SHORT SESSION NAME}
LENGTH := 1 ;                   {NAME LENGTH}

HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE ) ;
IF RET_CODE <> 0
   THEN BEGIN
   WRITELN ( 'ERROR 002: CONNECT FAILED FOR HOST' ) ;
   END ;
```

SEARCH PRESENTATION SPACE FOR HOST MESSAGE

```
FUN_CODE := 6 ;                 {API FUNCTION NUMBER}
RET_CODE := 0 ;                 {0 IF SESSION PARAMETER
                                 IS SRCHALL; OTHERWISE,
                                 START LOCATION OF SEARCH
                                 0 TO 1920}

COPYSTR('DIALED TO PRODDOS',DATA_STRING) ; {STRING TO SEARCH FOR}
LENGTH := 16 ;                  {SEARCH STRING LENGTH}

HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE ) ;
   IF RET_CODE = 0
   THEN BEGIN
   WRITELN ( 'ERROR 003: SESSION NOT VALID' ) ;
   END ;
```

COPY SIGN-ON STRING TO PRESENTATION SPACE

```
   IF RET_CODE <> 0
   THEN BEGIN
   FUN_CODE := 15 ;             {API FUNCTION NUMBER}
   RET_CODE := 161 ;            {POSITION TO COPY STRING TO}
   COPYSTR('SOSI,PASSWORD,NAME OF USER',DATA_STRING) ;
   LENGTH := 26 ;               {TOTAL LENGTH OF STRING}

   HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE ) ;
      IF RET_CODE <> 0
         THEN BEGIN
         WRITELN ( 'ERROR 004: SIGNON FAILED' ) ;
         END
```

SEND ENTER KEY AFTER STRING TO HOST

```
   ELSE BEGIN
   FUN_CODE := 3 ;              {API FUNCTION NUMBER}
   RET_CODE := 0 ;
   COPYSTR('@E',DATA_STRING) ;  {MNEMONIC FOR ENTER KEY}
   LENGTH := 2 ;

   HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE ) ;

   IF RET_CODE <> 0
      THEN BEGIN
      WRITELN ( 'ERROR 005: SIGNON FAILED' ) ;
      END ;
   END ;
```

WAIT FOR SYSTEM RESPONSE TIME TO COMPLETE CYCLE

```
FUN_CODE := 4 ;
RET_CODE := 0 ;
COPYSTR(' ',DATA_STRING) ;
LENGTH := 0 ;

HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE ) ;

   IF RET_CODE <> 0
   THEN BEGIN
   WRITELN ( 'ERROR 008: WAIT FOR HOST FAILED' ) ;
   END
ELSE
```

SEARCH FOR RESPONSE FROM HOST

```
FUN_CODE := 6 ;
RET_CODE := 0 ;
COPYSTR('VM/PRODUCTION LINE',DATA_STRING) ;
LENGTH := 18 ;

HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE) ;

   IF RET_CODE <> 0
      THEN BEGIN
      WRITELN ( 'ERROR 006: HOST NOT PRESENT' ) ;
      END
   ELSE BEGIN
```

COPY HOST SESSION SCREEN INTO PROGRAM WORK AREA

```
   FUN_CODE := 8 ;
   RET_CODE := 0 ;
   COPYSTR(' ',DATA_STRING) ;
   LENGTH := 1920 ;

   HLLPAS ( FUN_CODE, DATA_STRING, LENGTH, RET_CODE ) ;
   IF RET_CODE <> 0
      THEN BEGIN
      WRITELN ('ERROR 009: COPY FROM HOST HAS FAILED' ) ;
      END ;
   END ;
END ;
```

A PC application uses HLLAPI to intervene with the host. This Pascal code logs the user's PC onto the host mainframe system and copies a screen of data into the HLLAPI application work area. Before the actual logon takes place, the application first must set session parameters using function 9 and connect to the presentation spaces using HLLAPI function 1.

WAYS AND MEANS

To go the HLLAPI route, you need a PC with about 512KB of memory—enough to load and run DOS, the workstation software, the HLLAPI load module, a LIM if your application is written in a high-level language, and the PC application. On the host side, you need an interactive mainframe system, such as CICS, TSO, CMS, or VM.

You also need a host connection board. For the IBM 3270 Workstation Program, this means an IBM 3278/79 emulation adapter, SDLC adapter, or Token-Ring network board; the IBM entry-level 3270 Emulation Program supports a 3278/79 adapter only. Attachmate EXTRA! supports all of IBM's host-connection boards, plus Attachmate's own coaxial and SDLC adapters, as well as DCA's IRMA coaxial adapter. DCA's HLLAPI works with all DCA host-connection products (coaxial, modem, and LAN).

The HLLAPI versions from IBM, Attachmate, and DCA follow the same load procedure. Once the terminal-emulation software is loaded, you load HLLAPI. If the application is written in a high-level language, the appropriate LIM must be linked into the executable application program.

To initiate an HLLAPI application on the PC, first load DOS, then the workstation emulator, and finally the HLLAPI.EXE file. Memory requirements are as follows. DOS 3.3 takes about 55KB. For HLLAPI on the IBM 3270 Workstation, the workstation emulator

and HLLAPI.EXE take 178KB and 35KB, respectively. Using the Entry Level Emulator, an EEHLLAPI requires 21KB and 12KB, respectively. Attachmate's EXTRA! consumes 107KB, and its HLLAPI takes 37KB; DCA's E78 Emulator takes 38KB, and its HLLAPI, 51KB. Using a LAN to connect to the host adds the network software memory requirement.

Thus, IBM's workstation and HLLAPI consume 268KB of memory to load the basics, leaving 372KB for the application. While not meager, this limits application expansion. Attachmate's workstation and accompanying HLLAPI use 199KB—not bad, but you can do better. DCA takes a mere 144KB, leaving 496KB for applications and support software. Finally, if you can tolerate a much simpler emulation package that supports only a single mainframe session, consider IBM's EEHLLAPI, which takes only 91KB.

If you apply HLLAPI in a network environment, however, you should be prepared for memory shock. Loading the system files to support the network then the workstation programs and HLLAPI can leave you with a paltry 150KB of available memory.

Memory conservation notwithstanding, the down side to using HLLAPI is that it slows the speed at which data transfer takes place—not a trivial factor in host connections. This shows up especially in realtime operations. The difference may not be discernible to the average user, but some applications involving heavy PF-key use or large file transfers can take more time. String data may appear to be moving at lightning speed, but setting up a timer will show that the overhead introduced by the LIM-to-HLLAPI and back-to-LIM conversion can add precious seconds to system response time. User acceptance of the time differential could impact the decision on using HLLAPI at all.

Moreover, running HLLAPI through a LAN gateway can slow down the entire network. Most modem-connected LAN gateways effectively support four to six users, providing them with host communications as well as local services. A gateway runs only as fast as the communications line to which it is connected; thus, a 9,600-bps line supporting six simultaneous users results in an effective rate of transfer of about 800 bps. Your best bet would be a direct LAN connection to the host controller. (For example, a 3174-L controller with a Token-Ring interface coupler should be able to handle 32 users without a serious degradation in response time.)

HLLAPI SHOPPING

IBM's two versions of the interface are: HLLAPI 3.1, for use with the 3270 Workstation Program, and EEHLLAPI 1.2, which is included with the PC 3270 Emulation Program, Entry Level 1.2 (for a look at these emulators, see "Emerging 3270 Coherence," Mary DeWolf, August 1987, p. 194). EEHLLAPI provides all HLLAPI functions except the interception of keystrokes entered to the host session and support for an alternate presentation space. Both packages include HLLAPI, LIMs, a programmer's guide, and sample programs.

Telephone support service for IBM's current version of HLLAPI is available from IBM's National Support Center until March 5, 1989, and through local customer support thereafter. Questions and problems are answered in standard IBM format: be prepared to provide detailed identification and documentation of your question when you call.

Memory conservation notwithstanding, the down side to using HLLAPI is that it slows the speed at which data transfer takes place.

IBM HLLAPI is quite manageable if you can wade through the documentation. IBM alphabetized the functions instead of putting them in numeric order, so if you know the function number but not the proper name, you will spend time learning the index.

Attachmate HLLAPI and LIMs are bundled with its EXTRA! connectivity software; a programmer's guide and sample programs are included in the API Programmer's Tool Kit. The Tool Kit provides guidance for identifying potential HLLAPI applications and instructions on how to use the sample programs provided. A program that simulates a mainframe session is provided to allow a developer to perform initial testing of HLLAPI applications without being on-line to the host mainframe. Attachmate technical assistance is available over a toll-free line for questions regarding installation, use, and customizing of connectivity and HLLAPI software.

Attachmate is easy to use and to debug. Documentation look-ups are quick because the functions are in numeric order. The functions are the same as IBM's, and code written for use with Attachmate operates properly in an IBM environment.

DCA HLLAPI3 applications can be used on any machine that has a DCA terminal-emulation board. This assures that members of the established IRMA base who need to get into the HLLAPI business need purchase only HLLAPI3. DCA's Enhanced Support Service is free for the first 90 days once you return the Developer Services Registration Form. The staff is knowledgeable and takes the time to solve a user problem. Upgrades come at a price, but minor revisions are available if requested.

HLLAPI puts developers on a loftier route to host connectivity, enabling them to capitalize on one of the PC's major departures from mainframe terminals—its highly approachable and manageable interface—while maintaining access to the host. HLLAPI automates and simplifies this access transparently. Moreover, the interface is supported by multiple vendors, so HLLAPI applications run on machines with IBM, Attachmate, or DCA terminal-emulation boards and software, without modification. Such progress lets integrators look past the pragmatic concerns of making components work together and allows them to concentrate on doing the job well.

Attachmate Corporation
3241 118th Street SE
Bellevue, WA 98005
800/426-6283
EXTRA! Connectivity Software 1.2: $425; API Programmer's Tool Kit: $195
CIRCLE 341 ON READER SERVICE CARD

Digital Communications Associates Inc.
1000 Alderman Drive
Alpharetta, GA 30201-4199
404/442-4000
IRMAX 3270 DFT Terminal Emulation (board and software): $995; DCA HLLAPI3 1.0: $195
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IBM Corporation
900 King Street
Rye Brook, NY 10573
800/447-4700 for nearest dealer
3270 Workstation Program 1.1: $495; 3270 PC HLLAPI 3.1: $195; PC 3270 Emulation Program, Entry Level 1.2: $325
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Michael Triner is microsystems manager for Calkins Newspapers, in Levittown, PA.

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WINDOWS for DATA

M'soft Windows Compatible

"Onlt one package can be easily recommended" said *Computer Language* (June '87) reviewing nine window and data entry products for C. Complete field level functions specify prompt string, field length, data type, screen location, picture, target variable, entry rules, help messages, even functions to call for validation once data keyed in.

Windows for C is a subset. No data entry but all windowing functions. Unlimited windows can be made either to pop up or permanently overwrite the screen, scroll and highlight lists vertically and horizontally. Specify Compiler. Windows for Data: List **$295**, Ours **$259**. Windows for C: List **$195**, Ours **$149**.

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PANEL PLUS

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Panel Plus will operate in graphics mode via interfaces to graphics products it supports and can utilize the EGA's 43-line screen. Low-level I/O functions adapt it to various keyboards, screens, operating systems.

Panel's newest incarnation has every imaginable feature. A single screen design can have 1000 fields stacked as visual overlays up to 127 levels deep or as pop-ups. Groups of fields can be moved between levels. Screens can be output as compilable code or stored on disk for loading at run-time. Each field can be boxed, colored, multi-row, word-wrapped, and scrolled horizontally and vertically if larger than its on-screen view aperture. It can be assigned its own help and error message, can be told to accept certain characters, or to match a picture, and to check data after entry—proper dates, number ranges, etc.—using Panel's or your own validation routines. You can add your routines to Panel's test utility because even it comes as source. Fields are accessed in any order and control reverts to your application program after each field for choice of action.

For past Panelists, the new version has smaller and faster field and screen functions, tighter granularity, and an enhanced, reworked library. Major tool for the serious developer. List: **$495**, PC Express: **$395**.

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Source Code Control for Any Language

PVCS allows programmers, project managers, librarians and system administrators to control the proliferation of revisions and versions of source code in software systems. Independent programmers, the leading software publishers and LAN companies, and hundreds of Fortune 1000 companies rely on PVCS to store and retrieve multiple revisions of text. It maintains a complete history of revisions as an "audit trail", generates status reports, and uses intelligent "difference detection" to minimize disk space for each new version.

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Corporate PVCS	**$395**	**$329**
Network PVCS	**Call**	**Call**
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dBC™ is a series of C libraries from Lattice which creates, accesses and updates files identical to those of dBASE itself. So dBASE can read and update the files too.

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dBC's functions parallel all dBASE's file handling commands, many decomposed to permit direct data manipulation. Our versions of dBC mimic file formats for dBASE II and III and now dBASE III Plus makes your programs network ready!... as many stations as a network allows. Hands-off mode handles record and file locking and unlocking automatically. Close in functions give you direct lock/unlock control.

Supports all four memory models. dBASE II, III...List: **$250**, Ours: **$175**. dBASE III Plus...List: **$750**, Ours: **$595**. Call for Source Code Pricing.

Payment: We honor MasterCard, Visa, American Express (no surcharge), checks in advance, or funds wired to PC Express, c/o Chemical Bank, 126 East 86 St., New York, Account 034-016058. COD (U.S. only) for cash, money order, certified check (no fee). NY State, add sales tax. Purchase orders accepted from larger corporations and institutions at our discretion if you agree to net 30 days plus 2% a month late penalty thereafter.

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The C-Worthy™ Interface Library wraps an entire user interface around your application. Its full power can be summoned by only a few high level calls. Sound exaggerated? A single function call can set up a complete text editor in a screen window. Recently acquired by Solution System, over 600 pages of Documentation, Turbo and Quick C version and a complete Interface Library have been added.

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- Full context-sensitive help screen management takes over these chores and error messages. Automatic routines interrupt with pageable text windows explaining what to do next.

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DOS interface includes: Call System, Call Exec, Findfrst/Findnext for (*) and (?) file searching. Search the Path, subdirectory and file manipulation, command line argument parsing, date/time functions, DOS environment access, and much more. Other utilities also included.

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	List:	Ours:
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Call for Full Source Pricing		

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No longer. dBRIEF™, written in BRIEF's macro language, grabs hold of BRIEF and turns it into a complete dBASE III and III Plus programming domain. Using BRIEF's underlying shell capabilities and its own interfaces, dBRIEF can run external utility libraries, plus dBASE itself, and link to the Clipper™, Foxbase+™ and Quicksilver compilers, all with dBRIEF still loaded and running the show. It can do what BRIEF already does plus:

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- Create databases; index files; invoke Ashton-Tate's dFORMAT™ and dCONVERT™; draw lines and boxes.

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	List:	Ours:
FoxBase +Version 2.10	**$395**	**$247**
Unlimited Runtime	**$500**	**$333**
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Unlimited Runtime	**$700**	**$467**
FoxBase +/386	**$595**	**$397**
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Microsoft QuickBASIC 4.0: is a revolutionary concept in BASIC programming. It allows you to run, edit, debug, and run again. Our friends at Microsoft have eliminated the dreaded compile step. Whenever you edit your code QB4 automatically incorporates your changes, so that it can run a program of 150,000 lines in less than a minute.

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Microsoft Macro-ASSEMBLER	**$150**	**$109**
Microsoft QuickBASIC	**$ 99**	**$ 66**
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NOVELL: BTRIEVE, XQL, XTRIEVE
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Btrieve is a library of subroutines that allows the programmer to build a database application using any language. It takes complete charge of all file creation, indexing, reading, writing, insertion, deletion, forward and backward searching. Its balanced tree indexing scheme finds any key in a million in less than 4 accesses...That's fast!

Btrieve is multi-lingual also. It includes more than 20 language interfaces (including C, BASIC, PASCAL, FORTRAN). However if it turns out that you are using something a little unusual, worry not. The manual includes a chapter on how to write a language interface to Btrieve.

Btrieve's vital statistics are equally impressive. Files may have up to 24 indexes; fixed record length to 4090 characters; variable length to 64K; indexes to 255 characters; files of 4 billion bytes. Network support includes Novell, 3-COM, IBM PC NET, Software Link's Multilink and many others.

XQL is a relational database management system designed especially for programmers. Imagine being able to access your database with the ease of SQL (Structured Query Language) statements and still having the power to process that data right down to the byte level.

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The XQL system works in tandem with Btrieve and has an equally powerful chassis...No limit on the number of records per file. Max. file size is 4 gigabytes, Max. record size equals 4K, Max. indexes per file is 24. The one version works for single or multiuser systems, DOS Ver 3.0 or greater. All languages are supported.

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Report Option for printing customized reports, form letters, mailing labels & statements.

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Btrieve	**$245**	**$175**
Btrieve/N	**$595**	**$445**
XQL	**$795**	**$595**
Xtrieve	**$245**	**$220**
Xtrieve/N	**$595**	**$459**
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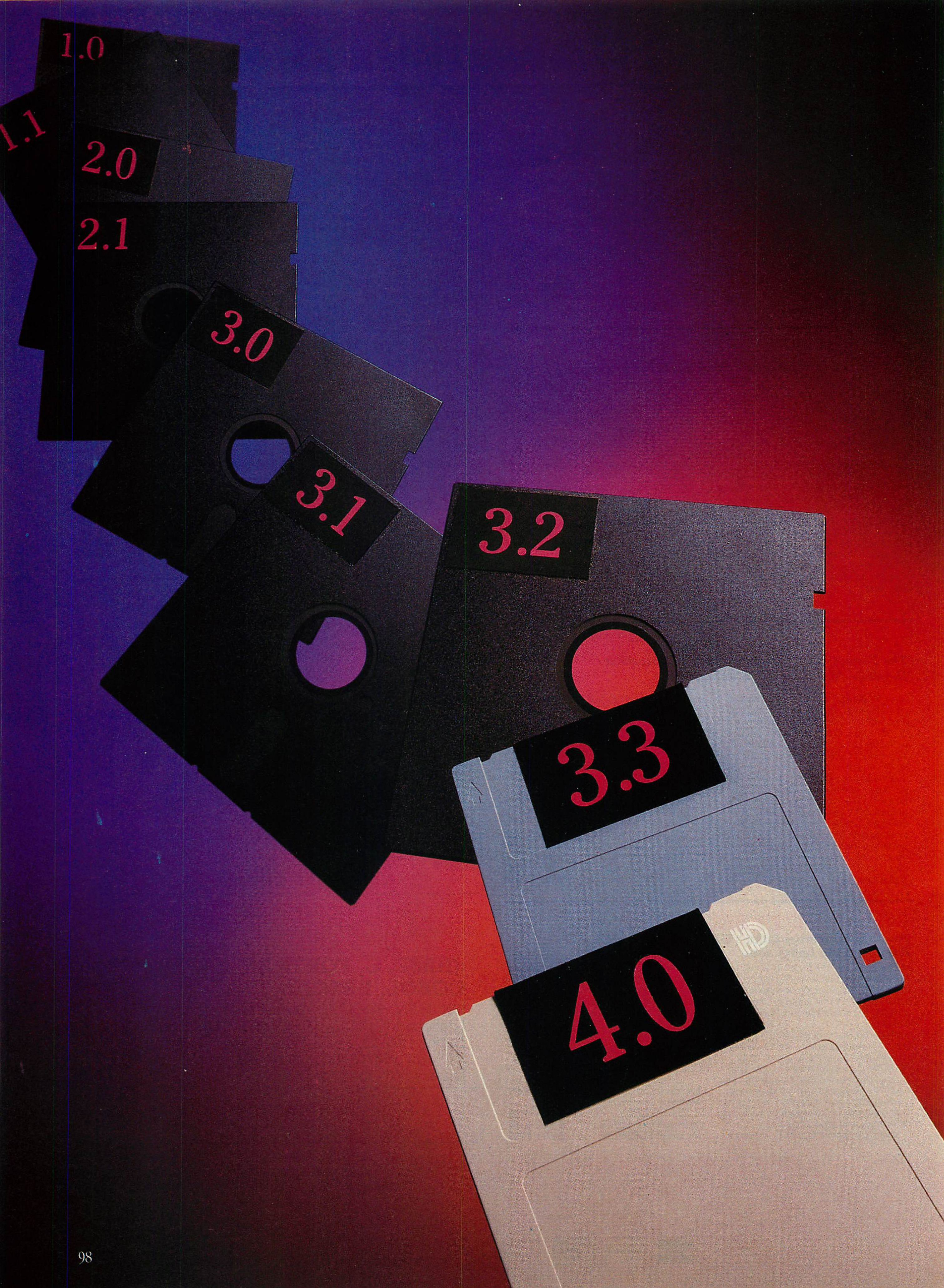
1.0
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4.0

DOS Marches on

Version 4.0 grants DOS a reprieve by adding a menu-driven interface, large disk partitions, and support for expanded memory.

RICHARD WILTON

DOS 4.0 is an operating system with a history. This ninth-generation DOS incarnation released last July does not have to win over large numbers of users to become the operating system of choice for single-user PCs; earlier DOS versions have already done this. It doesn't even have to replace its immediate predecessor, DOS 3.3, because that version will continue to be available from IBM. Rather, DOS 4.0's task is to modernize and rejuvenate the aging 7-year-old disk operating system for those who are committed to the DOS environment, but need it to be more functional.

Version 4.0 delivers the goods by introducing three important features whose absence in previous DOS versions frustrated many users: support for a full-screen, menu-driven user interface; large disk partitions; and support for expanded memory.

DOS 4.0's Presentation Manager-like user interface, called DOS Shell, makes DOS easier to use and incorporates windowing as part of the DOS environment for the first time. Use of 32-bit sector numbers allows a disk theoretically to be divided into four partitions of as many as 2 terabytes (TB) each. Large partitions are a definite advantage for systems storing large databases, for example. Further, DOS 4.0 can use the maximum amount of expanded memory on the system by installing EMS 4.0 drivers. This allows users to open as many as 10,000 disk buffers or establish a virtual disk in expanded memory, thus freeing space in low memory for application programs.

IBM views the primary niche for DOS 4.0 as "the installed base of hardware not capable of supporting OS/2," says IBM's DOS development manager Shon Saliga. For the millions of users who use DOS in an 8086- or 8088-based system, installing DOS 4.0 is a way to access larger memory and disk resources without buying a new system that can run OS/2.

New commands making their debut in DOS 4.0 include INSTALL, a CONFIG.SYS command to load terminate-and-stay-resident (TSR) programs (such as FASTOPEN.EXE, KEYB.COM, NLSFUNC.EXE, and SHARE.EXE) previously included in the AUTOEXEC.BAT file, and MEM, to display used, unused, allocated, and open memory areas. New drivers, installed using the DEVICE= command in CONFIG.SYS, include XMA2EMS.SYS to support EMS 4.0 and XMAEM.SYS to simulate the IBM PS/2 80286 Expanded Memory Adapter/A for accessing expanded memory on 386-based systems.

Most users also can benefit from enhancements to existing commands (see table 1). For example, BACKUP automatically formats an unformatted target diskette, and new BUFFERS parameters create as many as 10,000 disk buffers in expanded memory and specify the number of sectors the system can read ahead. FDISK presents full-screen displays of disk partitions, erases existing partitions, and creates new ones in megabyte or percentage sizes.

FASTOPEN now reserves a specified number (1 to 999) of continuous space buffers for the files on the identified drive to allow faster retrieval. In addition, three other commands now support an /X parameter to perform their functions in expanded memory: ANSI.SYS, to enhance I/O with various

PHOTOGRAPHY • RUMMEL/LUCAS

TABLE 1: ***Changes in DOS 4.0***

COMMAND	STATUS	DESCRIPTION
CONFIG.SYS COMMANDS		
BUFFERS	Enhanced	Supports look-ahead buffers; can use expanded memory.
FCBS	Modified	Has no effect if SHARE is not loaded.
INSTALL	New	Executes FASTOPEN, KEYB, NLSFUNC, or SHARE when CONFIG.SYS is processed.
REM	New	Indicates a comment.
SWITCHES	New	/K switch disables DOS processing of extended keys with enhanced keyboards.
DEVICE DRIVER COMMANDS (.SYS)		
ANSI	Enhanced	Provides additional support for enhanced keyboards and for VGA video modes.
COUNTRY	Enhanced	Supports Asian character sets.
DRIVER	Modified	No longer recognizes /N switch.
PRINTER	Enhanced	Provides additional IBM printer support.
VDISK	Enhanced	/X switch supports expanded memory.
XMAEM	New	Emulates expanded memory in an 80386-based system.
XMA2EMS	New	Supports expanded memory (EMS 4.0).
USER COMMANDS AND UTILITIES		
APPEND	Enhanced	/PATH switch optionally overrides explicit file-search path.
BACKUP	Enhanced	Automatically formats unformatted diskettes.
CHKDSK	Enhanced	Supports large disk partitions; displays allocation units (clusters) and volume serial numbers.
CLS	Enhanced	Recognizes additional video configurations installed using the MODE command and ANSI.SYS.
COMMAND	Enhanced	/MSG switch optionally loads error-message text into memory.
DEBUG	Enhanced	Provides access to expanded memory.
DEL	Enhanced	/P switch prompts the user before deleting.
DIR	Enhanced	Displays volume serial number.
DOSSHELL	New	Executes a full-screen, point-and-shoot user shell.
FASTOPEN	Enhanced	Has optional buffer optimization for fragmented files; /X switch supports use of expanded memory.
FDISK	Enhanced	Supports large hard-disk partitions (partition-table system indicator = 6); uses partition sizes in megabytes or percentage of available disk space.
FORMAT	Enhanced	Assigns volume serial numbers; /F switch allows formatting by specifying diskette media capacity.
GRAFTABL	Enhanced	Adds support for multilingual code-page 850.
GRAPHICS	Enhanced	Includes support for additional printers; allows customized printer configurations.
KEYB	Enhanced	/ID switch supports code pages with multiple keyboard layouts.
MEM	New	Displays memory usage.
MODE	Enhanced	Recognizes a new set of key-word parameters; provides additional support for video mode and code-page configurations; sets keyboard typematic rate.
REPLACE	Enhanced	/U switch updates files.
SELECT	Modified	Supports menu-driven interface.
SHARE	Modified	Required for use with hard-disk partitions larger than 32MB.
SYS	Enhanced	Recognizes an explicit source-drive specification.
TIME	Enhanced	Recognizes 12- or 24-hour clock.
TREE	Modified	Provides a graphic representation of subdirectory tree structure.
VOL	Enhanced	Displays volume serial number.

Improvements to DOS include two new device drivers, XMAEM.SYS and XMA2EMS.SYS, to support expanded memory; new commands, such as INSTALL, REM, SWITCHES, and DOSSHELL; and enhanced commands to improve the DOS environment.

keyboard and display features; FASTOPEN, to store in memory the location of directories and open files; and VDISK, to create a virtual disk.

Finally, DOS 4.0 integrates all these features and commands in a package that is fully compatible with DOS 3.3. All commands and system structures of previous DOS versions (see table 2) carry forward in version 4.0—including support for code pages and extended hard-disk partitions—making DOS 4.0 similar in functionality to DOS 3.3. (For a full review of DOS 3.3, see "Twilight of DOS," Julie Anderson, August 1987, p. 180.) Users can even ignore DOS 4.0's new Presentation Manager-like interface and access larger disk partitions and expanded memory in the familiar DOS command-line environment. More likely, however, they will opt to take advantage of the DOS Shell utility, which invokes the new interface.

DOS 4.0 costs $150, or $95 if the purchaser is upgrading from another version of DOS. DOS 3.3 continues to sell for $125, according to an IBM representative. The *DOS Command Reference* and *DOS Technical Reference* are $30 and $150, respectively. OS/2 Standard Edition 1.1 with Presentation Manager costs $325.

TABLE 2: *DOS Chronology*

VERSION	INTRODUCED	NEW HARDWARE SUPPORTED
1.0	August 1981	IBM PC
1.1	May 1982	Double-sided diskette drive
2.0	March 1983	Hard-disk drive (PC/XT)
2.1	October 1983	Half-height diskette drive (PC*jr*)
3.0	August 1984	1.2MB 5.25-inch diskette drive (PC/AT)
3.1	March 1985	IBM PC Network
3.2	December 1985	720KB 3.5-inch diskette drive (PC Convertible)
3.3	April 1987	1.44MB 3.5-inch diskette drive (PS/2)
4.0	July 1988	Large hard-disk partitions and EMS 4.0 support

Since its introduction in August 1981, DOS has been updated constantly to keep up with new hardware. The latest version supports expanded memory and larger disk partitions required by large applications and adds a friendly user interface.

INSTALLATION MADE EASY

DOS 4.0 is available on either two 3.5-inch 720KB diskettes or five 5.25-inch 360KB diskettes. (The additional utilities diskette is distributed with the *DOS Technical Reference*.) Users also must supply one blank diskette for installation on a hard disk. While a bit of diskette shuffling is still required, DOS 4.0's much-improved SELECT utility simplifies installation over previous DOS versions.

The SELECT command provides an easy-to-use, menu-driven facility with extensive context-sensitive help and configuration options for installing or reinstalling DOS without reformatting the hard disk. SELECT can copy DOS utility programs and device drivers either to diskettes or to a hard-disk partition and can create partitions on a hard disk that has none.

During installation, screens prompt for keyboard, country, and target drive and directory. The user can update all DOS files on the hard disk or copy all nonsystem files to a specified directory and can customize a DOS configuration or use the default. Customization options include expanded memory and VDISK support.

SELECT also sets some DOS parameters that can be modified, such as APPEND /E and PROMPT, and sets FASTOPEN parameters and configuration parameters including BREAK, BUFFERS, and FILES. It creates the AUTOEXEC.400 and CONFIG.400 files, which update AUTOEXEC.BAT and CONFIG.SYS files. The documentation includes instructions on how to install DOS 4.0 to coexist with OS/2 or other operating systems.

SELECT automatically formats an unformatted diskette prior to copying DOS 4.0 onto it. The command can install DOS 4.0 in a hard-disk partition that contains an earlier version of DOS without backing up the files and reformatting the partition or disk if total disk size is less than 32MB. The size of the partition remains the same; only the disk boot sector and DOS 4.0 system files are updated.

For current DOS users who want to enlarge an existing disk partition to greater than 32MB for use with DOS 4.0, the files in at least two partitions must be backed up and the partitions deleted with FDISK. Then, they can use SELECT to create and format a larger partition that occupies the space that was formerly divided into two or more smaller partitions.

DOS 4.0 consumes more memory than comparable installations with earlier DOS versions. For this latest iteration, IBM recommends a minimum 256KB of memory for DOS 4.0 and 360KB for a configuration that includes the complete DOS Shell. Users who stand to benefit most from DOS 4.0—those with expanded-memory hardware or large hard disks—should already have 512KB or 640KB systems.

The SELECT command has three options for increasing or decreasing the operating system's memory requirements, trading memory consumption for increased speed. These are (1) minimum DOS function/maximum program work space, which turns off all configuration options (such as FASTOPEN and ANSI.SYS) except DOSSHELL, and sets no buffers; (2) maximum DOS function/minimum program work space, which installs ANSI.SYS and DOSSHELL, starts FASTOPEN with 150 file and directory entry buffers and 150 continuous space buffers, and creates 25 disk and 8 look-ahead buffers (to read in as many as 8 sectors following the one accessed by the input operation); and (3) balance DOS and program work space, which is similar to the maximum DOS function, but with fewer disk and FASTOPEN buffers and no look-ahead buffers. Each additional disk buffer increases the resident size of DOS by 532 bytes, and look-ahead buffers by 512 bytes, thus leaving less memory for applications.

With SELECT's minimum DOS memory configuration, about 570KB is available to applications on a 640KB machine. (A minimum DOS 3.3 installation leaves about 590KB of free memory for applications.) When SELECT installs DOS 4.0 for maximum DOS memory usage, the amount of free memory for applications is approximately 540KB.

SELECT does not solve all installation problems for all users. Those who install a disk-cache utility, such as IBMCACHE.SYS or Microsoft's SMARTDRV.SYS, may prefer not to use DOS buffers. This must be done by directly editing the BUFFERS command in CONFIG.SYS. Moreover, SELECT cannot detect the presence of expanded-memory hardware. Users who want to configure a DOS 4.0 installation so the BUFFERS and FASTOPEN commands use expanded memory must also edit CONFIG.SYS directly.

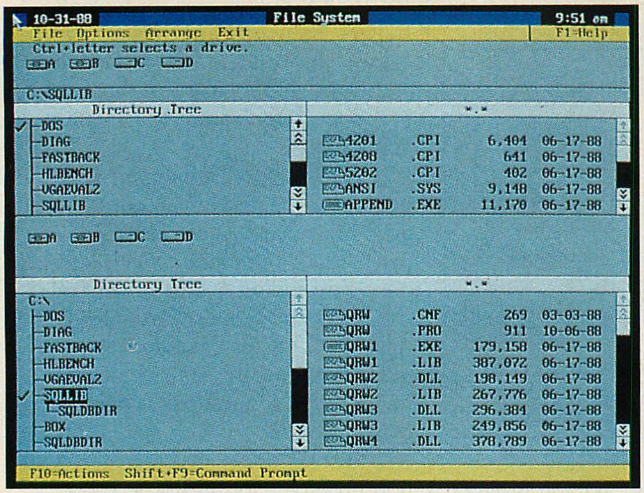
WINDOW TO THE WORLD

The point-and-shoot DOS Shell utility is the most striking new feature in the DOS 4.0 user interface—perhaps because it was so long in coming (in this age of user-friendly, graphics environments). DOS Shell is in line with IBM's commitment to the Systems Application Architecture (SAA) goal of standardizing its products. The keyboard or mouse-driven interface has the look and feel of OS/2's Presentation Manager: an action bar; a main-group menu; pull-down and pop-up menus; a tree-structured, disk-management system called File System; and a comprehensive, F1-driven, context-sensitive help facility. A set of full-screen, file-management functions in the File System menu option look and feel similar to the Apple Macintosh interface and Microsoft Windows environment.

However, unlike the other well-known, full-screen interfaces such as Presentation Manager and Windows, DOS Shell is only a DOS application—not an application programming environment. It is more limited in that it has no functions for developing and incorporating DOS Shell-like interfaces into developer-written applications.

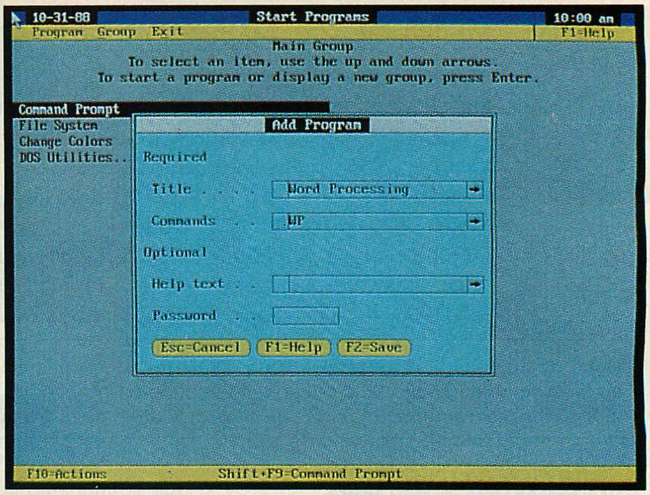
The user executes DOS Shell by entering the DOSSHELL command at

PHOTO 1: ***DOS Shell's File System***



The DOS Shell user interface has the look and feel of OS/2's Presentation Manager. This is particularly true of the File System, which can show two subdirectories at one time. It has a left window to graphically display directory structure, and a right window to list all files.

PHOTO 2: ***Customizing DOS Shell***



Users can customize the main-group menu selections by selecting either Program or Group (to add a nested group of programs) from the action bar. Pop-up menus prompt for a text description to appear on the main-group menu, the command to invoke the program, help text, and a password.

the DOS command prompt or by including it in AUTOEXEC.BAT or another batch file. (When SELECT installs DOS 4.0, the utility builds an AUTOEXEC.BAT file that ends with a DOSSHELL command.) A DOS Shell user can return to the DOS prompt through a DOS Shell menu selection.

The interface presents the user with an action bar (at the top of the main menu) and four main-group default functions. The action bar offers these selections: Program (to start a program; to add, change, delete, or copy one into a group; or add to or delete it from the list of main-group default functions), Group (to organize related programs and customize the main-group list of default functions), and Exit (to exit the shell).

Default functions are Command Prompt, to return to the familiar command-line interface of previous DOS versions; File System, to access file and directory catalogs; the Change Colors selector, to choose colors for the shell display; and DOS Utilities, to select DOS operations, including SET DATE, SET TIME, DISK COPY, and FORMAT.

The File System utility provides the richest set of functions, with the ability to execute or examine contents of a file selected directly from a directory list, to compare contents of two subdirectories using the Multiple File List selection from the Arrange pull-down menu, and to browse the subdirectory tree. This utility produces a split screen: the left window displays directories in a tree-structured format, the right one displays the names, sizes, and dates of creation of all files in the selected directory (see photo 1).

By comparison, the other default selections are uncomplicated. Command Prompt spawns a copy of COMMAND.COM, leaving approximately 9KB of the shell program resident in RAM; the Change Colors selection offers a choice of four shell color combinations; and DOS Utilities provides a menu-driven equivalent to common DOS commands.

While the default functions are enough to get started with DOS Shell, it is not difficult to customize the shell by adding new functions. The Program menu selection permits the user to associate any DOS command or utility with a title and a set of command-line parameters and add it to DOS Shell's list of available functions. For example, to add a selection that would run WordPerfect, the user selects the Program option, enters a text description (such as Word Processing) and executable-file name (WP) in fields in a pop-up window, and presses the F2 key (photo 2 is a screen shot of this example). From then on, the user need only select Word Processing from the main menu to execute WordPerfect.

DOS Shell also allows related programs to be grouped together through a Group command. Selecting the name of a group (for example, Graphics) then causes DOS Shell to display available selections in the group (for example, Dr. Halo or IBM Graphics Kernel System). Selecting one of these executes the program. This hierarchical grouping of functions is handy, but it is limited because DOS Shell supports only two levels.

Although SELECT installs DOS Shell with a default set of command-line parameters, DOS 4.0's *Getting Started* manual describes alternative DOS Shell options. The command DOSSHELL is implemented as a batch file (called DOSSHELL.BAT). The actual shell program, SHELLC.EXE, accepts many command-line parameters that specify the default video mode (text or graphics), the name of the mouse device driver, and other display and menu-configuration options. The start-up configuration of the shell can be changed simply by editing the SHELLC command-line options in the DOSSHELL.BAT file.

BREAKING THE 32MB BARRIER

One of the most annoying limitations of IBM's version of DOS throughout its history has been its inability to support hard-disk partitions larger than 32MB. This is most problematic in a system that processes large databases, where the files alone might be greater than 32MB and might have to be split and referenced on several extended partitions. This limitation became acutely evident in April 1987 when the IBM PS/2 Models 60 and 80 were introduced, with their hard disks in sizes that range upward from 44MB.

In all DOS versions, diskettes and hard-disk partitions are subdivided into

512-byte sectors numbered consecutively, starting at zero. In earlier versions, sector numbers are stored as 16-bit values, so the maximum number of sectors on a diskette or in a hard-disk partition is 65,536. Thus, the maximum size of a DOS partition is 65,536 sectors by 512 bytes, or 32MB.

To overcome the 32MB barrier, DOS 4.0 introduces 32-bit sector numbers, which theoretically can support partitions as large as 2TB. The larger sector numbers imply changes in several places in DOS, including disk formats, the interface-to-disk device drivers, and the application programming interface (API). Apart from the fact that DOS 4.0 supports disk partitions larger than 32MB, these changes are transparent to the end user. Applications programmers must be aware of them in order to find files efficiently on the disk and to use DOS interrupt and function calls successfully.

Increasing the available number of disk sectors also impacts DOS's file allocation table (FAT). Regardless of the size of a hard disk's partitions, the format of the disk remains unchanged. *The FAT* is a reserved area on every DOS disk that is used to allocate disk space to each file. Each entry in the table corresponds to a cluster of one or more contiguous sectors. Thus, the FAT maps the sectors that are allocated to each file on the disk. Like sectors, clusters are numbered sequentially with 12-bit numbers for diskettes and small disks (less than 16MB), and 16-bit values for disks larger than 16MB.

Problems with the design of the FAT become apparent as disk partition sizes increase. One potential problem can arise because the FAT size increases with the number of available sectors in a disk partition; the FAT can contain as many as 65,536 entries of 2 bytes each, so its size can increase to a maximum of 128KB. Because DOS must read the FAT into its internal buffers in order to use it, a large FAT can decrease the memory available to buffer disk-file data. With multi-megabyte files or files whose allocated clusters are scattered in a disk partition, overall disk performance may diminish as DOS accesses a large FAT.

In addition, because the number of clusters in a FAT is limited, the size of each cluster must be increased to accommodate very large disk partitions. For example, DOS 4.0 formats a 32MB partition with a 2KB cluster size (four 512-byte sectors per cluster); the maximum size of a partition that can be mapped is 65,536 times 2KB, or 128MB.

TABLE 3: ***Extended Boot Record and BPB***

OFFSET	LENGTH (bytes)	DESCRIPTION
00H	3	Jump to bootstrap code
03H	8	System ID
EXTENDED BIOS PARAMETER BLOCK		
0BH	2	Number of bytes per sector
0DH	1	Number of sectors per cluster
0EH	2	Number of sectors in reserved area
10H	1	Number of copies of FAT
11H	2	Number of root directory entries
13H	2	Total number of sectors
15H	1	DOS media descriptor
16H	2	Number of sectors per FAT
18H	2	Number of sectors per track
1AH	2	Number of heads (sides)
1CH	4	Number of hidden sectors
20H	4	Total number of sectors (if field at offset 13H contains zero)
BOOT-RECORD EXTENSIONS		
24H	1	Physical drive number
25H	1	Reserved
26H	1	Signature byte (29H)
27H	4	Volume serial number
2BH	11	Volume label
36H	8	Reserved

To handle partitions greater than 32MB, version 4.0 of DOS uses 32-bit sector numbers. To accommodate these, IBM extended the BIOS parameter block (BPB) by adding offset 20H to the boot record. If the number of sectors exceeds 65,536, offset 13H has a value of zero and 20H has the actual number of sectors. Boot record extensions store the new volume serial number.

For partitions of 33MB to 256MB, DOS uses a cluster size of 4KB; for partitions greater than 256MB, a cluster size of 8KB is used. Thus, the larger the disk partition, the greater the "granularity" of the partition's space allocation—in a 512MB partition, the smallest file consumes 8KB of space.

Fortunately, most PC and PS/2 users will not be greatly affected by the design limitations of the DOS file system. If, however, very large disk storage media achieve more widespread use, DOS users may find themselves needing to look elsewhere for better operating-system disk management.

The BIOS parameter block. Every DOS diskette and hard-disk partition is formatted with a BIOS parameter block (BPB) in its first logical sector (the *boot record*). The BPB contains information about disk media type and format, including number of FATs, size of the root directory, and number of sectors on the disk. Disk device drivers can use the BPB to describe the disk media format to DOS.

The DOS BPB specification uses a 16-bit field at offset 13H to contain the total number of sectors. To accommodate 32-bit sector numbers, DOS 4.0 uses an extended BPB format (see table 3), including an additional 4-byte field at offset 20H that contains the total number of disk sectors. If partition size exceeds 32MB, the system sets the total number of sectors to zero at offset 13H and places the actual number of sectors at offset 20H.

The extended BPB format is not a new concept. It was part of Microsoft's specification for DOS 3.2, introduced to allow OEMs to implement device drivers that use 32-bit sector numbers. However, IBM did not support 32-bit sector numbers in DOS hard-disk device drivers or in its API (in INT 25H and 26H) until version 4.0.

Volume serial numbers. The DOS 4.0 boot record contains information not present in the boot records in disks formatted by earlier DOS versions. The most important new information is a volume serial number, a 4-byte hexadecimal value that DOS generates from the current date and time during DISKCOPY or FORMAT routines. Although DOS 4.0 volume serial numbers appear random to a user, DOS uses them to identify disk volumes.

Volume serial numbers to identify diskettes provide an extra measure of

TABLE 4: *Changes to the DOS API*

INT	FUNCTION	CHANGE
21H	33H	New subfunction returns the boot drive ID
21H	44H	IOCTL provides double-byte character support (DBCS)
21H	65H	Extended country information now supports DBCS
21H	6CH	New function: Extended Open/Create
25H	—	Absolute Disk Read now supports 32-bit sector numbers
26H	—	Absolute Disk Write now supports 32-bit sector numbers

Only one new function (6CH) has been added to INT 21H; it combines three previous DOS functions (Open, Create, and Create/New). A new subfunction for 33H returns the boot drive ID. Other changes to 21H functions improve the foreign-language version of DOS. INT 25H and 26H now support 32-bit sector numbers.

data security in DOS. In OS/2, these numbers are more important. Because OS/2 is a multitasking operating environment, different tasks may try to access different diskette volumes in the same diskette drive. OS/2 uses diskette volume serial numbers to associate specific diskette volumes with tasks.

The serial number is displayed when a user invokes the CHKDSK, DIR, FORMAT, LABEL, or VOL commands. Thus, different diskettes have unique serial numbers, even if their user-assigned volume labels are the same, so DOS can distinguish different diskettes even though they have the same physical format.

This brings up a possible trap for DISKCOPY users. In earlier versions of DOS, DISKCOPY, not recognizing volume serial numbers, simply copies them from one diskette to another as part of the diskette's boot record. However, to ensure that copies of a diskette have unique volume serial numbers, users must invoke the DOS 4.0 version of DISKCOPY.

DOS 4.0 can use a diskette's volume serial number when SHARE.EXE is loaded to prevent errors that might occur if a diskette volume is changed in the middle of an I/O operation. For example, if a user opens a file on one diskette and then changes diskettes while that file is still open, DOS 4.0 issues an "Abort, Retry, Ignore, Fail" error message and indicates the volume serial number of the diskette it needs to complete the original I/O transaction.

MINOR API ALTERATIONS

DOS 4.0's API has comparatively few changes, most of which are a result of support for large disk partitions (see table 4). Because DOS 4.0 uses 32-bit sector numbers to manage partitions larger than 32MB, API functions that formerly recognized only 16-bit sector numbers now also recognize 32-bit sector numbers.

Only the API interrupts that directly address the disk, the Absolute Disk Read and Absolute Disk Write functions provided through software INT 25H and 26H, have been changed in DOS 4.0 to allow direct access to partitions greater than 32MB. Both functions bypass the DOS file structure and allow programs to access a disk on a sector-by-sector basis. These functions now accommodate 32-bit sector numbers while preserving compatibility with applications written under earlier DOS versions.

For disk partitions that are smaller than 32MB, the first sector number accessed through INT 25H or 26H is specified in register DX, the number of sectors to read or write is in register CX, and the address of an I/O buffer is in DS:BX. This particular specification is unchanged from previous versions.

With disk partitions larger than 32MB, however, DOS 4.0 uses the registers differently (see table 5). A value of −1 in register CX indicates a request for extended 25H or 26H. Registers DS and BX contain the address in RAM of a 10-byte *control packet*—a memory area that contains the starting sector number at offset 0, number of sectors to transfer at offset 4, and buffer address at offset 6.

This design has a catch. Although the control-packet interface can be used with disk partitions of any size, DOS 4.0 returns an error if a program tries to access a partition larger than 32MB with INT 25H or 26H, without using a control packet. The error occurs even if the program tries to access a sector within the first 32MB of the partition. This means that applications using the old INT 25H or 26H methodology will fail if they are run against data in a DOS 4.0 disk partition larger than 32MB.

TABLE 5: *INT 25H and 26H*

CALLING SEQUENCE

VERSIONS 1.0 THROUGH 3.3

AL = drive ID
CX = number of sectors to read or write
DX = starting sector number
DS:BX = buffer address

VERSION 4.0

AL = drive ID
CS = −1
DS:BX = control-packet address
offset 0 = starting sector number (4 bytes)
offset 4 = number of sectors to read or write (2 bytes)
offset 6 = segment:offset of data buffer (4 bytes)

Before 4.0, the number of sectors to read or write, the starting sector number, and the buffer address were in registers CX, DX, and DS:BX, respectively. To handle 32-bit sector numbers, DOS 4.0 uses −1 in CX to indicate a partition greater than 32MB, and DS:BX to hold the address of a control packet.

Support for double-byte character sets. Most other API changes are related to DOS 4.0's double-byte character set (DBCS) support, which, together with code-page switching introduced in DOS 3.3 (see the sidebar "Code-Page Switching" that appears in "Twilight of DOS," Julie Anderson, August 1987, p. 180), are important for support of foreign languages.

In international markets, DOS 4.0 needs to support non-ASCII character sets that use more than 256 different character codes, sometimes using two bytes to represent one character. DOS 4.0 processes a stream of characters by considering certain data values as *lead bytes* of byte pairs, which represent individual characters. DOS 4.0 maintains an internal table of valid lead-byte values (called the DBCS vector table) whose contents depend on the country specified in the COUNTRY command in the CONFIG.SYS file.

Under DOS 4.0, a program can inspect this table by executing INT 21H function 65H. Subfunction 7 returns the 32-bit address of the DBCS vector table. An application can use the table to determine which characters are represented as byte pairs instead of individual byte values.

Support for DBCS has also affected INT 21H function 44H I/O control for devices (IOCTL). Subfunction 0CH requests a device driver to perform code-page switching and can access or set the selected code-page ID for an I/O device. In DOS 4.0, this subfunction allows a DBCS vector table to be retrieved or updated along with the code-page ID if the programmer places either 4AH or 6AH in register CL to indicate the makeup of a parameter control block pointed to by register DS:DX. Because some device drivers support only code-page values, programmers must check the length returned in the parameter block to be sure the DBCS table has been returned. To date, only device drivers supplied with the Asian version of DOS 4.0 support this subfunction.

Although support for double-byte characters is listed as a "major new feature" in the DOS 4.0 *Technical Reference* manual, MS-DOS 2.25, released in 1985, supports extended non-ASCII character sets. MS-DOS 2.25 supported INT 21H function 63H (File Size), which included a set of subfunctions that processed double-byte characters by using a lead-byte table whose structure was similar to that of the table used in DOS 4.0. This function disappeared in DOS 3.0, but some of its capabilities are resurrected in a different form in version 4.0.

New API functions. DOS 4.0 has a new INT 21H function (Get/Set System Values, 33H), formerly a more limited function called Ctrl-Break check. Get/Set System Values returns the drive ID of the disk drive used to boot the system. A program can get the drive ID by placing the function number (33H) in register AH, the subfunction number (5) in AL, and executing INT 21H. DOS 4.0 returns the boot drive ID in register DL. A return value of 1 indicates the boot drive was A:, while a value of 2 indicates drive B:, and so on. This illustrates continued inconsistencies in DOS because in DEBUG, 0 indicates drive A:, 1 drive B:, and so on.

Extended Open/Create (6CH) is a new INT 21H function that integrates the services provided by DOS for creating and opening files. It unifies the INT 21H functions, Open (0FH), Create (16H), and Create New (5BH), although they are also still available individually. A program can use the values in a set of bit fields in registers BX and DX to control how DOS opens an existing file or creates a new one (see table 6). If creating or opening a file is successful, the file handler is returned in register AX and the action taken in register CX is as follows: 1 means the file is opened, 2 means the file is created and opened, and 3 means a file is replaced and opened. If not successful, an error code is returned in register AX.

TABLE 6: ***Bit-field Values for INT 21H Function 6CH***

BIT	MEANING	VALUES
FIELDS IN BX		
0–2	Access code	0 = read only 1 = write only 2 = read/write
3	Reserved	
4–6	Sharing mode	0 = compatibility 1 = deny read/write 2 = deny write 3 = deny read 4 = deny none
7	Inheritance	0 = child process inherits handles 1 = child process does not inherit handles
8–12	Reserved	
13	INT 24H handling	0 = enabled 1 = disabled
14	Commit to disk after each write	0 = disabled 1 = enabled
15	Reserved	
FIELDS IN DX		
0–3	If file exists	0 = error 1 = open 2 = open and truncate
4–7	If file not found	0 = error 1 = create new file

The bit fields in register BX control access to the file to be created or opened, while the bit fields in register DX indicate the actions to be taken.

The new twist to function 6CH is the ability to disable INT 24H to simplify critical error handling. When DOS detects a critical error (an error that occurs when a DOS function cannot be completed, such as "Printer out of paper" or "Sector not found"), it normally executes software INT 24H, the traditional DOS critical-error handling mechanism. The default DOS INT 24H handler issues the familiar "Abort, Retry, Fail" message. To override the default, a program must substitute its own INT 24H handler.

Function 6CH offers a way to return critical errors directly to a program. When a file is opened with a function 6CH call with bit 13 of register BX set to 1, DOS disables INT 24H for subsequent I/O transactions with the file. When a critical error occurs, DOS sets the carry flag and returns an error code in register AX without executing INT 24H, just as it does for noncritical errors (such as "Access denied," "Insufficient memory," or "Unknown command"). This allows the program to use INT 21H function 059 to get the error, class, location, and suggested action (such as "Retry after user intervention"), to try to correct the situation, or to print a message on a specified line on the screen to retain the integrity of the screen.

EXPANDING MEMORY

In the three years since its introduction, EMS 4.0 has become the method of choice for providing DOS applications with more than the default 640KB of conventional memory. DOS 4.0 is the first DOS version to be supplied with EMS 4.0 device drivers and to improve its own performance by taking advantage of expanded memory.

The EMS covers both hardware and software and requires hardware that can map multiple pages of physical memory into a single range of CPU addresses. The software specification describes an Expanded Memory Manager (EMM) that provides an API through software INT 67H. In practice, the EMM is implemented as part of an installable device driver tailored to a specific memory hardware configuration (see "EMS 4.0 Pulls Together," Ted Mirecki, July 1988, p. 72).

DOS 4.0 does not require expanded memory to run. Like most applications that recognize EMS, DOS 4.0 uses expanded memory only if proper memory hardware is present and an EMM device driver is installed.

IBM's EMS device drivers. For the user who has a PC or PS/2 with IBM expanded-memory hardware, DOS 4.0 is distributed with two installable EMS device drivers, XMA2EMS.SYS and XMAEM.SYS. XMA2EMS.SYS contains the EMM and supports EMS 4.0. This device driver is designed for use with one of the following IBM memory add-ons: 2MB Expanded Memory Adapter, PS/2 80286 Expanded Memory Adapter/A, or PS/2 80286 Memory Expansion Option.

XMAEM.SYS is for use only in 386-based machines. It programs the 386 control registers to implement a page-oriented memory-addressing scheme to emulate IBM's PS/2 80286 Expanded Memory Adapter/A. In a 386-based system, a developer must install XMAEM.SYS before XMA2EMS.SYS.

The developer must configure XMA2EMS to use a variable amount of available memory as expanded memory. Any RAM not allocated for use as expanded memory remains addressable as protected-mode extended memory. XMA2EMS does not, however, use any of the first megabyte of RAM on the system board as expanded memory. This means that extended memory is available in a system that has 1MB of RAM. The user should install XMA2EMS so that the amounts of conventional, expanded, and extended memory conform to the memory requirements of DOS 4.0 and the applications that will be running.

A PS/2 Model 60 with an IBM Expanded Memory Adapter/A, for example, might be configured with 1MB of RAM on the system board, of which 640KB is conventional and 384KB is extended memory. By default, the 2MB of RAM on the adapter also appears as extended memory, so a system without expanded memory has 640KB of conventional RAM and 2,432KB (2MB plus 384KB) of extended memory.

When XMA2EMS is installed and configured to use the maximum amount of expanded memory, all RAM on the adapter is treated as expanded memory and page-mapped by the device driver into conventional memory. A system with this configuration contains 2MB of expanded memory for use in programs that recognize EMS, such as Lotus 1-2-3, Microsoft Windows, or DOS 4.0 itself. The remaining 384KB of extended memory could be used by Microsoft's HIMEM.SYS and SMARTDRV.SYS drivers or IBM's disk cache driver (IBMCACHE.SYS).

This configuration forces a trade-off in conventional memory, where the expanded-memory device drivers are installed. For example, XMA2EMS occupies approximately 19KB; IBMCACHE uses 16KB; Microsoft's SMARTDRV uses 14KB. In practice, a user probably needs to sacrifice about 32KB of conventional memory in order to exploit expanded memory.

EMS device-driver alternatives. DOS 4.0 users may not necessarily want to use XMA2EMS or XMAEM. If developers install DOS 4.0 in a system with non-IBM EMS hardware such as the Intel AboveBoard, they must use the proper AboveBoard driver. Also, software manufacturers such as Quarterdeck (which makes DESQview) supply EMM device drivers that can be used instead of XMA2EMS with IBM expanded-memory hardware. The important point is to use a device driver that conforms to EMS 4.0 and that recognizes available expanded-memory hardware.

How DOS 4.0 uses expanded memory. Three DOS functions have been enhanced to use expanded memory if it is available. These functions, BUFFERS, FASTOPEN, and VDISK, require that two 16KB pages of expanded memory be reserved by XMA2EMS for their exclusive use; the pages are not available to other applications. XMA2EMS has two command-line parameters (P254 for VDISK and FASTOPEN, and P255 for BUFFERS) that reserve the appropriate expanded-memory pages. If the corresponding parameters appear on the DEVICE=XMA2EMS command line in CONFIG.SYS, then the /X switch used with BUFFERS, FASTOPEN, and VDISK causes them to allocate their buffers in expanded memory instead of conventional memory.

Although DOS uses expanded memory for its own buffers, there is no DOS-specific programming interface to expanded memory. Applications that use EMS memory use the INT 67H API, which is supported entirely in XMA2EMS or in another hardware-specific EMM device driver. A program cannot question DOS to discover whether an EMM device driver is installed or whether DOS itself is using expanded memory. An application must still inspect the INT 67H vector or search for a device named EMM*xxxx*0 before it makes INT 67H calls.

Two DOS 4.0 utilities recognize the presence of expanded memory. MEM reports on the amount of expanded memory available; DEBUG supports several new commands, including EMS Status (XS) to show the status of expanded memory, and EMS Map (XM) and EMS Allocate (XA) to manipulate expanded-memory pages.

BEHAVIORAL DISORDERS

DOS 4.0 sometimes misbehaves when used with expanded memory. Although the operating system reserves two expanded-memory pages for use with BUFFERS, FASTOPEN, and VDISK, it does not properly identify the pages it is using to the EMM, so non-IBM EMS devices drivers do not know what pages to use.

While there have been scattered reports of some problems using expanded memory under DOS 4.0, none were encountered with the IBM PS/2 Model 50Z and Model 70 test systems. Using BUFFERS with the /X parameter successfully placed buffers in expanded memory. FASTOPEN and VDISK were also successfully loaded into expanded memory, provided that at least one buffer was placed there first. Several TSRs, including Multisoft's Super PC-Kwik and Living Videotext's Ready!, executed successfully in expanded memory.

IBM has released maintenance upgrade 4.01 of DOS, which is intended to resolve any problems. Through its dealer and customer service representatives, IBM distributes a set of patch and replacement files that effectively upgrade version 4.0 to version 4.01. DOS 4.0 owners can go to their dealer or representative to have the latest fixes copied onto their diskette at no charge under the IBM warranty, says an IBM spokesman.

In its license agreement, IBM warrants the DOS 4.0 software as well as the diskette media on which it is distributed. The warranty period both for the software and for the media is three months. If a diskette fails within three months of the delivery date, IBM will replace it; if the software has bugs, IBM will try to fix them or replace the program. This is a departure from the warranty offered for previous versions of DOS, in which IBM warranted only the media, not the software.

Although DOS uses expanded memory for its own buffers, there is no DOS-specific programming interface to expanded memory.

DOS 4.0 NOVELTIES

Beyond those already described, DOS 4.0 includes a few other changes to aid developers. The new MEM utility returns a detailed map of DOS memory usage, including expanded and extended memory allocation. When executed without command-line switches, MEM provides a brief summary of memory usage similar to CHKDSK in earlier DOS versions, except MEM includes expanded and extended memory usage. When executed with the /PROGRAM switch, MEM provides additional information on memory-resident programs. The /DEBUG switch causes MEM to add information on installable device drivers and low-memory areas reserved for DOS or ROM BIOS use.

DOS 4.0 recognizes three commands in CONFIG.SYS not supported in previous DOS versions. The REM command allows comment lines to appear in CONFIG.SYS (to document the commands), the SWITCHES command provides an option that disables extended keystroke processing for the keyboard (to allow programs that do not recognize extended keystrokes to run unchanged with PC/AT and PS/2 keyboards), and INSTALL executes programs such as FASTOPEN and SHARE.

To process commands in the CONFIG.SYS file, DOS 4.0 executes all DEVICE commands before it executes INSTALL, regardless of their order in the file. This means that device drivers are loaded into memory at lower addresses than TSRs loaded with INSTALL. Interrupts redirected by both a device driver and a TSR program loaded with INSTALL are processed first by the TSR, then by the device driver.

BUFFERS has been enhanced with the parameter /X to specify from 1 to 10,000 disk buffers in expanded memory and a parameter to specify from 1 to 8 sectors that can be read ahead into RAM. Using read-ahead buffers can significantly increase performance of disk-intensive programs (see "The Cache Factor," Maxine Fontana, August 1987, p. 168).

The SHARE utility, as in earlier DOS versions, supports file sharing. In DOS 4.0, it must be used if a hard-disk partition larger than 32MB is defined. DOS 4.0 tries to install SHARE.EXE after CONFIG.SYS processing is complete by using the path specified in the DOS SHELL command. The SHARE.EXE file must reside either in the root directory or the same directory as the command processor specified in the DOS SHELL command. To override SHARE.EXE's default file space (2,048 bytes) or number of file locks (20), a user must include the /F and /L parameters when invoking SHARE.EXE.

Many other utilities and commands carried forward from previous DOS versions have new command-line switches that represent functionality not present in earlier DOS versions (see table 2). In the MODE command, for example, familiar but cryptic command-line parameters (such as M, N, and T) are replaced with English-like key words (such as LINES and COLS). The pre-DOS 4.0 parameters are still supported, however.

Another change is the one made to the TREE command, which displays directories in a block-graphic format with indents for subdirectories, rather than just scrolling the directories on the screen. A convenient modification

is the /U parameter of the REPLACE command, which replaces only files having an earlier time or date than that on the source diskette.

FORMAT command-line switches have been simplified. To support the many diskette formats (360KB, 720KB, 1.2MB, and 1.44MB) recognized by DOS 3.3, FORMAT in that version uses a confusing set of switches that specifies the number of tracks and sectors that correspond to a particular diskette format. In DOS 4.0, FORMAT recognizes an /F switch that simply specifies a diskette's formatted capacity. A 720KB diskette can be formatted in a 1.44MB 3.5-inch drive simply by executing FORMAT A: /F:720 instead of FORMAT A: /N:9 /T:80.

DOS error handling and error messages have been reworked for consistency and specificity in version 4.0. For example, errors in DOS 4.0's CONFIG.SYS cause configuration processing to display a message that shows which command caused the error. DOS 4.0 also has improved command-line syntax checking and error messages.

In DOS 3.3, a command such as DIR *.* /V produces the message "Invalid parameter;" in DOS 4.0, the corresponding error message is "Invalid switch - /V," which identifies the error more exactly.

Not all enhanced DOS commands are better than they were originally—some are just different. For example, DOS 3.3's temperamental APPEND command still has anomalies. In the previous DOS version, issuing APPEND followed by DIR would cause DOS to search the directories named in the APPEND command for a given file, but would report it as if it were actually in the current directory.

In DOS 4.0, APPEND with or without the /X parameter, which allows APPEND to search and process executable files, fails to perform directory searches with some commands. DIR, XCOPY, PRINT, ATTRIB, and BACKUP return "File not found," while MORE, TYPE, EDLIN, FIND, and DEBUG find the file. COPY, CHKDSK, and COMP find the file only when the /X parameter is used with APPEND. These problems are among several inconsistencies that continue to plague DOS and thus frustrate users.

THE LARGE AND SMALL PRINT

The documentation IBM supplies with DOS 4.0 contains much of the same material found in previous DOS manuals. It is distributed in three packages. The *Getting Started* and *Using DOS Version 4.0* manuals are packaged together. *Getting Started* covers installation, hard-disk partitions, and DOS Shell, and *Using DOS* covers the DOS file system, batch files, device-driver installation, system configuration, and DOS commands.

The *Command Reference* is a separately packaged manual, which costs an additional $30. It fully describes all DOS commands with syntax diagrams for all switches, parameters, and options. Casual users of DOS 4.0 might be satisfied with the *Using DOS* manual, but the *Command Reference* is for those who need a more complete reference. Anyone installing and configuring a DOS system will find full descriptions of commands such as FASTOPEN and GRAPHICS only in the *Command Reference*.

Not all of the enhanced DOS commands included in version 4.0 are better than they were originally—some are just different.

IBM also provides, at extra cost ($150), the DOS 4.0 *Technical Reference*, which documents the API. It is of little interest to end users but, as in previous DOS versions, is the primary source of complete documentation for programmers. The manual describes the programming utilities LIB, LINK, EXE2BIN, and DEBUG, and provides details on the programming interface for applications and for device drivers. It contains information on the changes and additions occasioned by DOS 4.0's support for expanded memory and large hard-disk partitions.

The *Technical Reference* has been completely reorganized and presents information in new and sometimes unfamiliar ways. For example, the descriptions of interrupts and functions now present examples of code rather than register contents and remarks only. Descriptions of some topics, such as ANSI.SYS, have moved to the *Command Reference*. For seasoned *Technical Reference* users, the newest release might take some getting used to.

Although DOS 4.0 contains some novelties and systematic enhancements, it has no surprises. Expanded-memory support, large hard-disk partitions, and a full-screen user shell have long been available as DOS add-ons from vendors other than IBM. The significance of DOS 4.0 is that these features are now bundled together into a neat little package.

DOS 4.0 also adds a twist to the relationship between DOS and OS/2. Like DOS 4.0, OS/2 addresses memory, partition, and shell enhancements, but the two operating systems have these sharp differences:

- OS/2 provides multitasking and full support for multiple concurrent applications; DOS 4.0 is still a single-tasking operation.
- OS/2 supports extended (protected-mode) memory and can therefore be used only in an 80286- or 80386-based system; DOS 4.0 supports expanded (bank-switched) memory if a system is equipped with memory hardware that conforms to the EMS and software specifically modified to use EMS;
- OS/2 offers a complete API for Presentation Manager; DOS 4.0 does not have an API for DOS Shell; therefore, DOS Shell cannot be incorporated into applications. To write a DOS 4.0 program with a Presentation Manager-like interface, a software developer must use Microsoft Windows.

DOS 4.0 allows a more flexible choice of hardware (8086, 8088, 286, and 386) than OS/2 and will remain a viable operating system for some time to come. Even so, OS/2 remains the IBM solution for users who need multitasking on the PC.

The latest version of DOS should appeal to users who have expanded memory capability on their hardware, do not need multitasking, and want to stay in the DOS environment. It is another step in the long line of updates, propelling this seasoned operating system into the ranks of more functional systems.

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Richard Wilton is a fellow in UCLA's Medical Informatics Program. He is author of the book Programmer's Guide to PC and PS/2 Video Systems *(1987) and coauthor of* The New Peter Norton Programmer's Guide to the PC and PS/2 *(1988), both published by Microsoft Press.*

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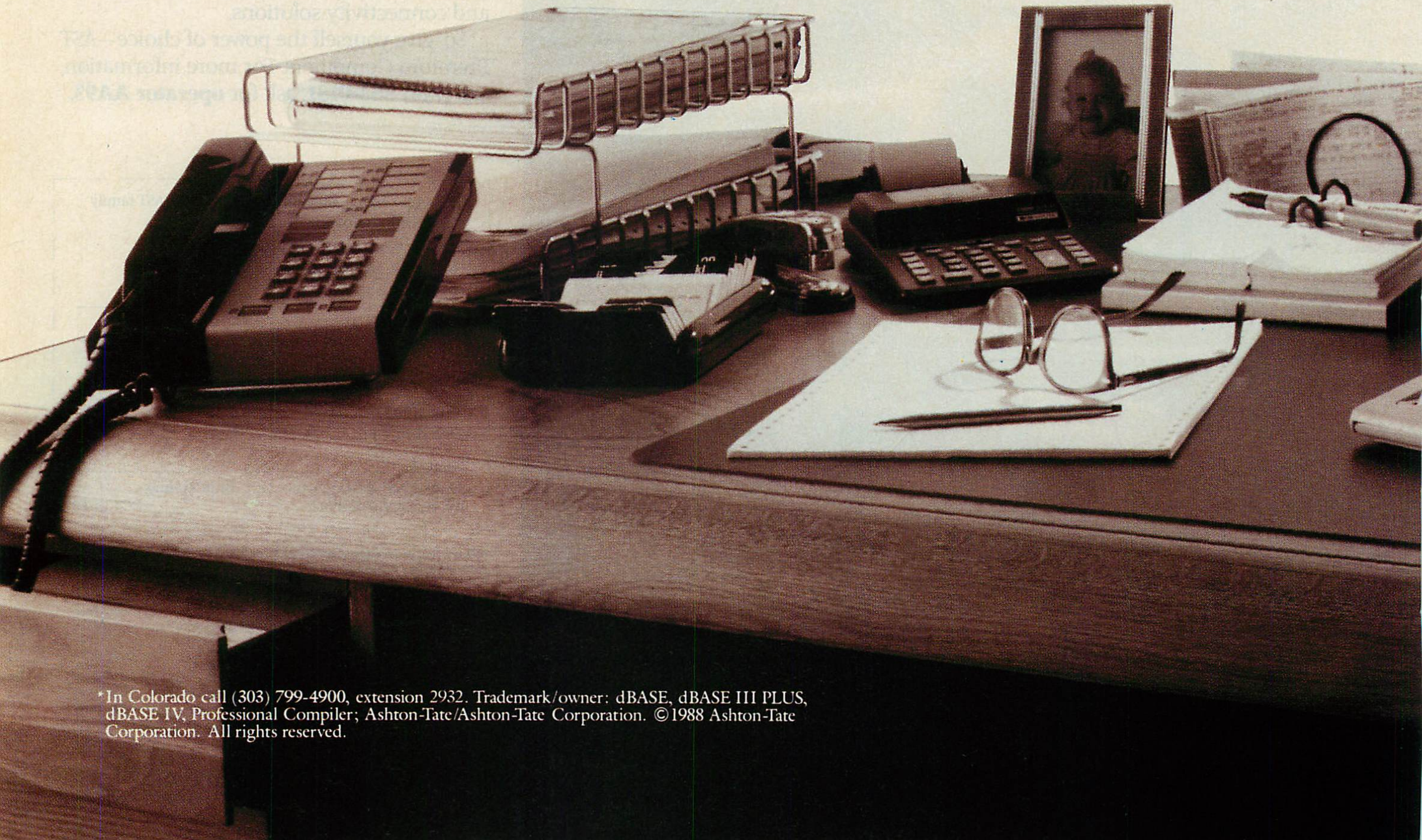

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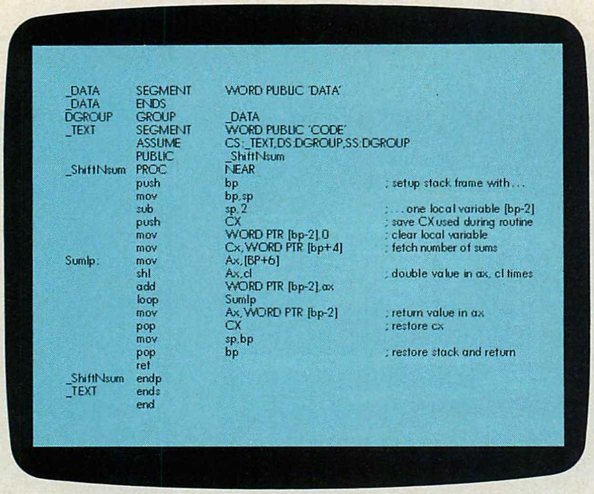

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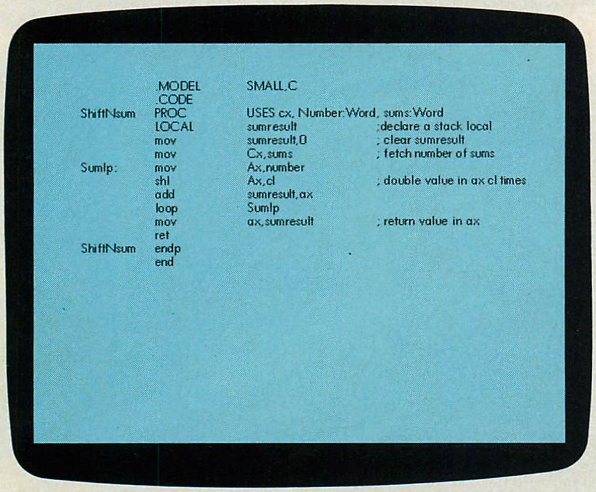

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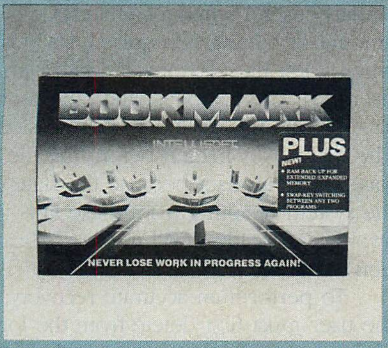

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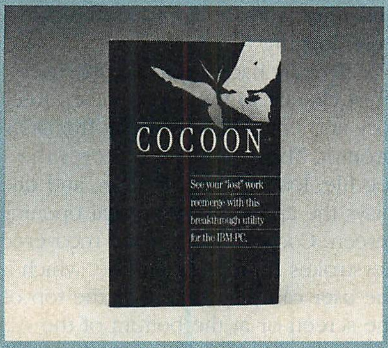

CIRCLE 357 ON READER SERVICE CARD

Every PC user has experienced one of the following disasters: a power failure wipes the system's memory clean, the user accidentally exits an application before saving files, or a faulty program crashes the system. Regardless of the cause or how frequently the user saves the data, valuable time and information can be lost.

Bookmark Plus 1.1 from Intellisoft International and Cocoon 1.0 from Daybreak Technologies are two software products designed to protect the user against this loss. While they achieve the same goal, they do so using completely different techniques.

Bookmark Plus saves the contents of the memory and processor registers in a disk file, a process that Intellisoft calls *placing a bookmark*. Reading these data back from disk into their original locations in memory completely restores the system, which includes the original cursor position. Cocoon, on the other hand, records all keyboard input from the moment the user starts an application. To recover data, the user plays back the keystroke log to the desired point.

AN OPEN BOOK

The standard version of Bookmark saves 640KB of DOS memory in addition to the video buffer. Bookmark Plus also saves extended and expanded memory. Both versions require local hard disks and neither can save bookmark files on network devices. Intellisoft plans to release a laptop version that monitors the state of the battery and places a bookmark when the battery nears exhaustion.

As a terminate-and-stay-resident (TSR) program, Bookmark Plus requires 29KB of memory. The program places bookmarks either automatically or on request when a hot key is pressed. Bookmark Plus also includes a programming interface so software developers can code applications to call Bookmark Plus, save the information, and return to the application.

The time required to place each bookmark depends on the amount of memory and the speed of the computer and hard disk. For example, it takes 15 seconds to place a bookmark on an 8-MHz IBM PC/AT with 2MB of memory and a 28-ms hard disk.

Bookmark Plus writes memory images to a hidden disk file, which the user can further protect with a password. The size of the hidden file is slightly larger than the sum of the system and video RAM. When loaded, Bookmark Plus looks for this file; if it is found, the program gives the user a choice of either restoring the previous state of the machine or continuing without restoring.

One strategy for using the program is to maintain two bookmark files, with bookmark placements written alternately to each. This ensures that even if a power failure occurs during a bookmark placement, a recent file will exist from which to restore.

Although Bookmark Plus works without any major problems, the basic concept of saving an entire RAM image reduces the appeal of this type of program. Placing bookmarks with the hot key may take more time and certainly requires more disk space than an application's save function. In addition, with the automatic bookmark placement, the user is interrupted as the computer periodically freezes while Bookmark Plus writes the contents of RAM to disk.

Intellisoft has included two features that are designed to deal with these interruptions, but they are only partially successful. A Do Not Disturb mode postpones bookmark placement until the keyboard has been idle for a specified interval; this is designed to place bookmarks during the occasional pauses that often occur during a work session. While this feature helps to some extent, bookmarking time-outs can still occur when least desired.

The Concurrent Text mode allows the system to accept keyboard entry and display it on screen while Bookmark Plus saves the data (this works only in text mode). The synchronization between keystrokes and screen display is poor, however. The user can type 5 to 10 keystrokes before all the characters appear on the screen at once. As long as these problems do not excessively disrupt your working rhythm, you will find that Bookmark Plus does an excellent job of saving and restoring data.

Bookmark Plus really shines, however, when it is used for what its name suggests—as a bookmark to return to a particular place in an application. If your usual practice is to resume working each morning exactly where you left off the day before, you can place a bookmark and then power down without exiting your application. Then, performing a restore will put you back in the application exactly where you left off. This feature can be particularly useful if you run several programs at one time under a multitasking system such as Quarterdeck's DESQview. A single bookmark can save your place in each application and restore all of the programs at once.

WORD FOR WORD

Unlike Bookmark Plus, Cocoon is not a TSR program. The program remains resident (occupying 12KB) only while logging an application's keystrokes. The command LOG followed by the application's name (and any command-line options) loads Cocoon and the application, and starts the logging process. When the user exits the application, Cocoon also terminates.

The user can configure the program to be completely transparent. Batch files automate the process of starting applications indirectly through the package. The logging process does not noticeably affect the application's keyboard response.

Cocoon maintains a separate log file for each application (a maximum of 256 files). All of the log files, named COCOON.LOG, are kept in different directories, which requires that each application also be in its own directory.

While Cocoon will run with most TSR programs (such as Borland's SideKick), it may not be able to log keystrokes that were entered while the TSR program was active because many TSRs take control of the keyboard, intercepting keystrokes before they get to Cocoon. Once the user exits the utility and returns to the application, however, logging resumes.

To play back a log file, the user must change to the appropriate directory and enter RECOVERY at the DOS prompt. This command retrieves the log file, loads the application, and displays the application's normal opening screen. Cocoon displays the recovered keystrokes on a message line, which the user can place at either the top of the screen or at the bottom of the screen to avoid conflict with the application's screen.

Cocoon plays back the logged keystrokes either manually or automatically. In manual mode, the package plays back one keystroke each time the user presses any key. In automatic mode, it plays back keystrokes as fast as the application will accept them. Pressing any key returns Cocoon to manual mode, allowing rapid progress through many keystrokes to a point where manual intervention is required.

During manual playback, the user can edit the playback log by either inserting or deleting characters. As characters are played back, the message line scrolls to the left so the next line of characters to be recovered is always displayed. The user can terminate the recovery process at any time by holding the Ctrl key down and pressing the F9 key twice. Requiring the user to press the F9 key twice reduces the chance of inadvertently terminating the recovery process.

Cocoon utilities translate log files to and from ASCII format, allowing editing using any text editor. This is particularly useful when a significant amount of editing is required, such as when a log file gets out of synch with data files. This happens when the user saves a data file during a work session. The keystrokes logged before the file save are redundant because the state of the system resulting from these keystrokes is already saved in the application's data file.

To perform an accurate recovery, the user must first delete from the log file all keystrokes that occurred before the most recent file save. If the data loss was a result of a user mistake, such as exiting an application without saving it first, it is important to delete

keystrokes from the end of the log file so the recovery process will not duplicate the mistake.

Cocoon log files have other uses besides recovering lost data. Program developers can replay the same sequence of keystrokes repeatedly during the debugging process, using Cocoon's debug utility that allows keystrokes from a log file to be passed to an application program running under a debugger. Log files can be tutorials and demos; by editing the log file and inserting the WAIT command at strategic locations, playback will occur at an appropriate speed.

Cocoon will run on most network stations and log to a local hard disk, but will not log to a server's hard disk. The log file name, COCOON.LOG, is wired into the program and cannot be changed; so, users cannot work in the same network directory at the same time. Cocoon is a well-behaved DOS program and will run in the DOS compatibility box of OS/2.

THE CHOICE IS YOURS

One difference between Cocoon and Bookmark Plus involves nonkeyboard input and could be significant depending on the applications the user runs. Cocoon will not save input from serial ports, from mice or other pointing devices, or from specialized links such as IEEE-488. Bookmark Plus handles all of these inputs, to the extent that they are reflected in the computer's memory when a bookmark is placed.

Bookmark Plus also has a simpler restore function, requiring only a single command. In the process of saving, however, Bookmark Plus can cause annoying interruptions. Lengthening the time between saves only widens the window for potential data loss.

Cocoon's save function, on the other hand, is both transparent and continuous. Although this avoids some of the objections users may have to Intellisoft's approach, it has its own problems on the other end of the process during restoring. Users must carefully monitor the playback of the comprehensive input log to repeat only the desired actions.

Choosing between Bookmark Plus and Cocoon depends on the user's work habits and a preference between ease of saving and recovery. While both products have some limitations, both accomplish the same important goal—to protect the user from losing time, data, and money.

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The developers of the EXSYS expert-system development package had one goal in mind: to create an expert-system shell that permits both domain experts and software developers to create expert systems. To satisfy the needs of experts, EXSYS Inc. offers EXSYS, the basic development package. For developers creating more complex systems, the company sells EXSYS Professional, an advanced expert-system development package. The professional version has all the features of EXSYS, but also has an interface to dBASE III files to allow direct access to data during execution, a rule compiler to convert standard text files to EXSYS format, and a command language to control execution.

EXSYS is a rule-based expert system shell—that is, it stores all knowledge in a knowledge base in the form of IF . . . THEN . . . ELSE rules. One of the major reasons EXSYS is easy to use is its simple and efficient rule-building procedure. Other important features are the choice of several approaches to handling uncertain data, several search strategies, versatile interfacing with external programs, and useful troubleshooting aids.

On a PC with 640KB of RAM, each expert system developed with EXSYS can store almost 5,000 rules. Expert systems larger than this can be developed by tying together several systems using EXSYS's Blackboard, a facility that permits interaction among knowledge bases. Each knowledge base updates the Blackboard for use by the other knowledge bases. While this approach to large systems is not as efficient as frames (knowledge structures used by hybrid shells to organize knowledge), it is much simpler. For an explanation of frames, see "Computerized Reasoning," Tom Arcidiacono, May 1988, p. 44.

EXSYS version 3.2.15 is available for the IBM PC, PC/XT, PC/AT, and compatibles. It requires 320KB of RAM (640KB is recommended), two diskette drives or one diskette drive and a hard disk, and DOS 2.0 or later. EXSYS Professional 1.1 requires a hard disk and a minimum of 512KB, although 640KB is recommended. Both programs are written in C for speed and flexibility and are also available for VAXes and some Unix systems.

EFFICIENT RULE BUILDING

Several EXSYS features streamline the process of building a knowledge base. These include the program's screen layout, automatic rule-part sequencing, and automatic syntax checking.

The layout of the screen provides a logical and organized work environment for building a knowledge base. The screen is divided into three windows: a Rule Display Area on the left-hand side, which shows the rule being created; a Condition Work Area on the right-hand side, which shows rule elements; and a Menu Area at the bottom, which displays available commands.

The easiest way to create rules is with the Rule Editor, which performs automatic rule-part sequencing. EXSYS prompts for and automatically sequences through the five components of an EXSYS rule: IF, THEN, ELSE, NOTE, and REFERENCE. EXSYS first displays the rule number and the component IF in the Rule Display Area. The developer defines and enters up to 127 conditions into the Condition Work Area. When definition is complete, the system automatically enters the conditions into the Rule Display Area and repeats the sequence for the next two rule components (THEN and ELSE).

The last two components, NOTE and REFERENCE, are optional. NOTE records supplemental information, such as author and date, which is displayed when the rule is displayed. REFERENCE stores additional information that is not displayed. When rule definition is complete, EXSYS automatically sequences to the next rule number.

A small sample expert system (an accident-responsibility system) was developed to test EXSYS for this review. The system determines whether a

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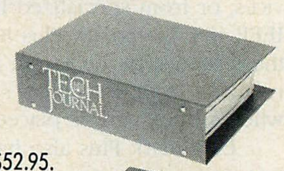

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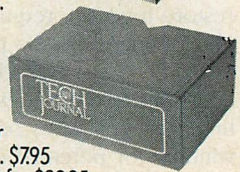

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driver is responsible for an auto accident. The following is a rule from the sample system:

IF
 the judgment of the driver was good
 the speed the driver traveled at was appropriate
 and the maneuver the driver made was proper
THEN
 the driver is not responsible for the accident

The conditions in the IF statement are composed of qualifiers (judgment of the driver) and their values (good, fair, and poor).

Rule conditions also can contain choices that are the possible results or goals. In the sample system, the choices are:

The driver is responsible for the accident
The driver is not responsible for the accident

Using the menu at the bottom of the Rule Editor, a developer can add, edit, delete, print, and store rules. Selecting one of these options displays a submenu. For example, the menu for adding rules displays seven options, including add a new qualifier, recall the previous qualifier, search all qualifiers for a text string, copy a condition, set a choice value, add a mathematical expression, and get help.

The Rule Editor menu options are designed to assist developers in reusing qualifiers and conditions in other rules. For example, to write another rule that also refers to the judgment qualifier in the sample expert system, the developer searches on "judgment." The system displays the qualifier and its associated values: "The judgment of the driver was: 1. good, 2. fair, 3. poor."

If the developer chooses 2 (fair), the system displays "the judgment of the driver was fair" under the IF statement in the Rule Display Area. With this system, elements need only be defined once. The system does, however, have a flaw: the larger the number of qualifiers, the longer it takes to search for a specific qualifier.

EXSYS automatically checks rule syntax during the rule-building and editing process. If a symbol, such as a bracket, is left out, the system displays an error message. The system also checks for validity, logical consistency, and redundancy.

HOW CERTAIN ARE YOU?

The EXSYS developer can choose from three different methods of dealing with uncertain data (data whose values are not known with absolute certainty). The most commonly used techniques are the deterministic method and the confidence-factor approach. The deterministic approach treats each statement as either true or false and is most appropriate if uncertainty is unknown or unimportant. The confidence-factor approach assigns each statement a value between 0 and 10 (from least to most certain), depending on the degree of confidence that the data values are true. EXSYS combines confidence factors by averaging.

If the expert can substantiate probabilities, the latter approach is the most appropriate. With this method, the developer assigns each statement a number between −100 and +100 (from least to most certain). The developer can direct EXSYS to average the probabilities, multiply them as percents, or combine them using a system formula. With the confidence factor and probability approaches, multiple solutions, each with different probabilities, are possible. For example, a possible conclusion to the example expert system could be Driver A is responsible for the accident (+80) and Driver B is responsible for the accident (+20).

CONTROL OF SEARCH STRATEGY

EXSYS is primarily a backward-chaining system—the user must enter a goal that the system attempts to satisfy. However, it also permits backward chaining only, forward chaining only, or combinations of backward and forward chaining.

Running EXSYS with the Forward option causes the program to test rules in the order they occur and to use backward chaining to derive additional information needed to verify the conditions in the rules. Specifying both the Nobackward and Forward options causes forward chaining only and is very fast. No information is derived by backward chaining; rather, the user is queried when inferencing requires additional information.

The Rule Organizer utility controls searches. The Rule Organizer command, Faster, rearranges rules in a

backward-chaining knowledge base to increase execution speed. It should not be used with forward chaining, because it changes rule numbers and thus the sequence of operations.

EXPERT TROUBLESHOOTING

EXSYS interfaces with external programs at the start of an expert-system run; calls programs from the IF, THEN, and ELSE parts of a rule; reads records from and writes records to databases; and can automatically restart programs. It also has several features to help troubleshoot an expert system, including Why and How commands, a Display Rule option, and a Trace command. The developer can also use the Rule Organizer to help spot problems.

The Why command displays the rule that prompted the system to query the user for more information. The How command explains how the system reached its conclusion by presenting the rule with this conclusion in its THEN part. When any of the IF conditions in this rule are selected, the system will report which rule determined that its condition is true. In addition, the Display Rule option displays all rules used during a consultation.

The Trace command, which the developer sets before the system runs, is useful for pinpointing the source of a logical flaw. It traces the complete sequence of events and shows which rules fired and which values were set.

The Rule Organizer also is useful in testing the logic of an expert system. If changing the sequence of rules gives different results, a logic error probably exists in the knowledge base.

EXSYS also allows the user to ask a "what if" question during a consultation with an expert system. This is done after running a knowledge base and obtaining results; the user selects menu choice C (change) and modifies the answer to one or more of the questions asked during the consultation. EXSYS displays the results of the two runs side by side. This feature also is useful for developers attempting to evaluate and fine-tune the expert system being built.

PROFESSIONAL PROGRAM

EXSYS Professional has many features to increase the programmability of the system. Among these are the Command Language, the Rule Compiler, and the Custom Screen Definition Language.

The Command Language includes commands to control flow (GOTO, IF . . . ELSE . . . ENDIF, and WHILE . . . WEND), run named subsets of rules using either forward or backward chaining, access DBASE III files directly, call external programs, and display screens. Using the command language, developers can write command files that can conditionally execute related expert systems, call other command files, and execute a block of rules when a condition is true.

The Rule Compiler allows developers to create and edit rules with any word processor and translate them into exact EXSYS format. The Custom Screen Definition Language permits the developer to produce interactive screens for the end user using a text editor. It includes commands to format the screen, position the cursor, draw borders, select color, set pauses, and create custom help files.

EXSYS has easy-to-use features for the domain expert; EXSYS Professional adds powerful programming features for the developer.

EXSYS Professional also has more ways than EXSYS of handling probability. In increment/decrement mode, a rule can add or subtract points from a total for the choice; if a choice is selected by many rules, it will have more points, indicating a higher confidence that it is the correct choice. This is useful when many independent factors contribute to the suitability of a choice.

Custom formulas provide the most flexibility for determining the final confidence for a choice. Developers can write their own formulas for calculating confidence; these can include confidence levels for qualifiers and values that are solicited from users, set by the developer, or derived from rules. In handling confidence, EXSYS Professional competes favorably with many large hybrid shells, such as Texas Instruments' Personal Consultant Plus. (For a review of this product, see "Sophisticated Expert," Susan J. Shepard, July 1988, p. 106.)

A SYSTEM OF CHOICE

EXSYS is a popular expert-system development tool, primarily because it does not require extensive programming experience. EXSYS has easy-to-use features for the domain expert; EXSYS Professional adds powerful programming features for the developer. The domain expert can easily build small systems for diagnosis and classification applications. Using the programming power of EXSYS Professional, the experienced programmer can build larger and more complex expert systems.

EXSYS is a rule-only system; therefore, all knowledge must be contained in its rules. This contrasts with a hybrid shell in which knowledge is structured into frames or objects that can inherit information from ancestors. In a hybrid shell, the rules can reason about the knowledge in the frames or objects and, as a result, can provide more complex inferencing. EXSYS, however, is a versatile rule-only shell that can solve many problems without the complexity of structuring knowledge. The Blackboard feature and EXSYS Professional's Command Language compensate to a certain degree by allowing interaction among several small expert systems.

EXSYS has more choices for handling uncertainty than are usually supplied by expert-system tools. The EXSYS inference engine is also flexible; although basically a backward-chaining system, the engine permits some forward chaining. Rule search in EXSYS is very simple: the developer searches according to the order of rule entry. EXSYS Professional allows subsets of rules to be executed.

For end users, consultation is extremely simple. All questions are multiple choice and the user answers with the number corresponding to the choice. EXSYS also gives explanations and confidence factors for final choices and displays the rules used.

EXSYS does have a few drawbacks, however. For example, the program's inability to use the operator between the values of the two qualifiers means that the developer will have to write more rules. In addition, although EXSYS searches for qualifiers so the developer does not have to reenter them, search times increase as the number of rules in the system increases.

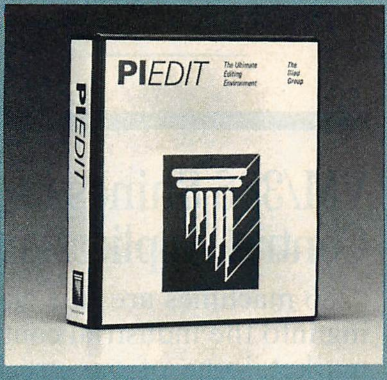
Note, however, that both of these problems are relatively minor. Both EXSYS packages are simple to use, and neither requires previous expert system experience. At $395 for the basic package and $795 for EXSYS Professional, either program is an excellent tool for entering the expert system development arena.

—PAUL SIEGEL

PI EDIT 2.1

The Iliad Group
2697 Union Street
San Francisco, CA 94123
415/563-2053

PRICE: $195



CIRCLE 353 ON READER SERVICE CARD

One of the latest entries into the crowded field of program editors is The Iliad Group's PI Edit 2.1. What sets this package apart from many other established editors is its ease of use. PI Edit also features a macro language, the capability to edit multiple files in multiple windows, and the ability to invoke a compiler without exiting the editor. At the present time, only DOS versions are available, but the Iliad Group plans to release OS/2 and Unix versions. PI Edit 2.1 requires both 192KB of RAM (640KB is recommended) and DOS 2.0 or later.

Because of a systematic organization of commands into logical groups, PI Edit is easier to learn than many other editors, including Solution Systems' BRIEF, Lugaru's Epsilon, and Unipress's EMACS. Most commands in the default configuration consist of two keystrokes beginning with the Ctrl key. All Delete commands, for example, start with Ctrl-D and all Window commands start with Ctrl-W.

If the user pauses after typing the first letter of a command, a menu showing the possible commands beginning with that letter appears. This feature certainly makes PI Edit easy to learn, although two keystrokes are required to execute a command where other editors require only one. The user, however, can configure PI Edit so that single keystrokes are bound to commands.

PI Edit has optional configuration tables that enable it to emulate BRIEF's commands. This invalidates some of the on-line help information, although the user can edit the key-assignment file. The Ctrl-D key combination, for example, cannot be the first keystroke of a Delete command because BRIEF emulation requires Ctrl-D to signify "scroll buffer down."

Although in some cases, PI Edit's features are less powerful than other editors, its features are more accessible to the average user. For example, macro languages found in program editors commonly offer more features than most users will ever learn, but tend not to be easy to read or use. PI Edit's macro language, on the other hand, is very readable, with a slightly Pascal-like appearance, and comes with a source-level debugger.

All serious program editors can compile a file being edited and display any error messages in a window at the touch of a few keys. PI Edit goes one step further with built-in syntax checking. It can also interpret error messages produced by most compilers and highlights the line in the source file that contains the error.

PI Edit does not have an Undo command similar to BRIEF's (which reverses the effect of any command), but its Delete Undo command restores the text from any multiple-character Delete command. It is more akin to PI Edit's own Yank command than an Undo command; each deletion puts the deleted text into a unique buffer, and the Delete Undo command restores text from any of these buffers to the current cursor position.

Regular-expression searches use an idiosyncratic notation, different from both BRIEF and standard Unix regular expressions. The Iliad Group departed from the established form of regular expressions to be consistent with DOS wild cards for file name generation. This consistency is not achieved, however, because DOS wild cards do not make sense as a base for regular expressions. For example, *X.C as a DOS wild-card expression matches all file names with extension .C, not just those with names that end with X.C, whereas *X.C as a PI Edit expression matches only lines containing X.C.

A more powerful and useful innovation is the All option of the Locate String command. This feature allows the user to isolate all lines of a file that match a specified pattern and view them in a separate window. These lines appear in their own window, but they are still part of the original edit buffer. Even though the lines appear contiguous in the window, this ingenious feature keeps track of their real locations in the file when changes are made.

PI Edit's performance is excellent in searching, inserting, and moving around a file. The program is somewhat sluggish, however, during the initial load of a large file. The editor searches a 130KB file in 2 seconds, compared with a 4.6-second search of the same file by BRIEF. PI Edit takes 13 seconds to load the same file, compared with 3 seconds for BRIEF. Because of different methods used by the two editors, these are not exact comparisons but illustrate general performance.

As with most DOS editors, the size of files the user can edit is limited by available RAM; if PI Edit 2.1 runs out of memory during an edit session, it displays an appropriate error message and refuses to do anything that would increase the size of the file. The corresponding situation when attempting to write to a full disk, however, is handled less gracefully. Instead of telling the user that the disk is full (usually an easily recoverable situation), the program emits the panic-inducing "disk I/O error" message.

The documentation consists of a reference manual in an eight-by-nine-inch, three-ring binder and a useful quick-reference card, a thoughtful addition to the other reference materials that more publishers should include.

As this review went to press, The Iliad Group announced the availability of version 3.0 of PI Edit. According to the company, the new version takes advantage of expanded memory and is shipped with two copies of the program: one for editing in virtual memory and the other for editing small files in RAM only.

The new version also adds support for the Ada compilers from Meridian Software Systems and the Modula-2 compiler and assembler from Jensen & Partners International and directly supports more than 25 compilers and a dozen languages. PI Edit version 3.0 costs $195 and requires 256KB of memory and DOS 2.1 or later.

Although PI Edit has some solid virtues, the limited, nonstandard implementation of regular expressions is a drawback. The programmer who uses an editor every day may prefer one of the alternatives on the market. However, because it is easy to learn and has some unique, worthwhile innovations, PI Edit is a good choice for the occasional user.

—NICK JACOBS

Multitasking Software Surprises Experts

"I went through every multitasker that was made for 386 computers, and none of them worked," one user told us. That same person, interviewed in a recent customer survey, said "VM/386™ is one of the finest pieces of software I've ever used...it actually does what it's supposed to do."

Apparently it isn't easy to find a true multitasking product. Those who have been looking for some time have even rejected other packages.

"We had pretty much given up on a multitasker," another user told us. "We got VM/386, and have subjected it to every piece of nasty code we're capable of writing. We have not even been able to get it to burp...I am impressed."

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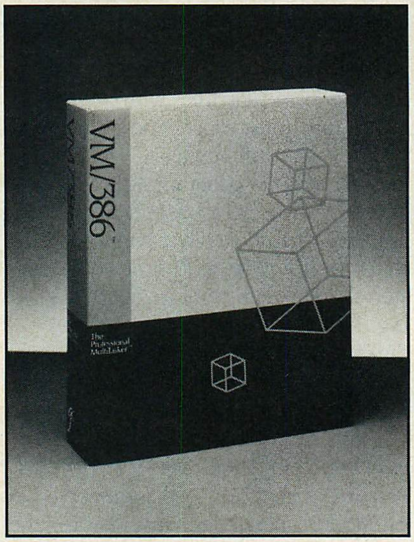
VM/386 makes your computer think that it has more than 640K of memory. In fact, it makes each application think it has its own 640K of RAM—which is especially useful for network drivers.

That's why one user told us to "Forget multitasking! It's kind of handy, I admit, but our people don't do big sorts that often. They *do* load up RAM-resident programs, until they run out of room. VM/386 gets around this problem. I fell in love with it as soon as I found out it really worked."



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VM/386 Shines in Control Applications

"386 machines are just blasting into the industrial control market," one of our process control experts told us. He had considered OS/2, and had tried other multitasking products. "They crashed on us," he says. Then he tried VM/386. "The overhead was less than 3%, just like they advertised," he says.

He has told other companies about VM/386. "They're as pleased as I am that there's one that works. It's a phenomenal piece of software. (And) the support is excellent."

OS/2 is a trademark of IBM.

CIRCLE NO. 257 ON READER SERVICE CARD

TED MIRECKI

TECH NOTEBOOK

A forum for sharing solutions to technical problems

1 386 DEBUG

Debugging is such an integral part of computing that it is supported in the very silicon of microprocessors. In Intel's 8086 and 8088 chips, this support consists of single-step and breakpoint interrupts that a software debugger can use to step through a program being tested.

Although the 80286 processor provides a significant increase in computing power, it brings nothing new in debugging support. The 80386, on the other hand, brings a big increase in hardware-assisted debugging facilities. It adds three types of debugging interrupts, and provides several architectural features to support them. A 386-specific debugger can offer some of the power formerly available only through add-in hardware-assisted debuggers. (For a review of hardware debuggers, see "Hardware Assistance," Marty Franz, this issue, p. 58.)

This month's item describes in detail the debugging support built into the hardware, and presents a demonstration of interfacing these facilities to an existing software debugger.

1 80386 DEBUGGING SUPPORT

The primary hardware-supported debugging facility consists of eight debugging registers labeled DR0 through DR7. Two of these, DR4 and DR5, are reserved for internal chip functions and are inaccessible to programs. The other six are accessible by move instructions in the following form:

```
MOV DRx,zzz
MOV zzz,DRx
```

where *x* is 0, 1, 2, 3, 6, or 7 and *zzz* is one of the 32-bit general registers EAX, EBX, ECX, EDX, EDI, or ESI. The instructions can be executed in both real and protected modes; in the latter, they can be executed only at privilege level 0 (the highest).

Each of the registers DR0 through DR3 can hold a breakpoint address. The address must be in 32-bit linear form, after segment translation, but before conversion from a virtual to a physical address by the paging mechanism. If paging is not enabled, a linear address is equivalent to a physical address; in real mode, it is calculated by shifting the segment address left four bits and adding the offset.

The debug control register, DR7 (see figure 1), selectively enables each breakpoint address and defines the breakpoint conditions. For each debug address register, DR7 contains two enabling bits: a local enable bit and a global bit. If either bit is set, the corresponding breakpoint address is active, and accessing memory at that address generates an INT 1. The read/write bits specify the type of access that causes the breakpoint: instruction fetch, data write, or either data read or write. For data accesses, the length bits specify a range of as many as four bytes to be monitored at each address; a breakpoint occurs if the specified access occurs at any byte within the range. For breakpoints on instruction accesses, the length bits must be zero; if the instruction has prefixes, the breakpoint address must point to the first prefix.

Two-level enabling facilitates debugging in a multitasking virtual-memory environment. At each task switch, the processor automatically resets all four local enable bits. This disables the breakpoints for which the global bits are not set, preventing unwanted debug interrupts in the new task. If a breakpoint remained enabled, unwanted debug interrupts could occur because the linear address in a debug register is not necessarily unique to a task. With memory paging active, two or more tasks could use the same linear address to refer, via different paging tables, to different physical addresses. The debugger software would turn on the global enable bits when debugging globally accessible code, such as a device driver.

Note, however, that a task switch unconditionally clears the local enable bits in DR7 without saving them, and the bits remain clear when the debugger task regains control. To handle this condition, a debugger program can set the debug trap bit of its task switch segment (TSS). This generates an INT 1 every time the task resumes execution. When the debugger's interrupt handler determines that the INT 1 was caused by a task switch, it sets the local enable bits. The interrupt handler then resumes execution at the point where the task was last suspended.

The LE and GE bits in DR7 establish exact data breakpoint matching. Normally, the 386 overlaps data writes to memory with execution of the following instructions. In these circumstances, an interrupt caused by writing to a data breakpoint address may occur when the instruction pointer points one or more instructions past the instruction that performed the write. But, when either LE or GE are set, the CPU slows down its execution to wait for the completion of writes before proceeding with the next instruction. Intel's *386 Programmer's Reference Manual* recommends setting one or the other bit whenever data breakpoints are enabled. The LE bit is cleared at each task switch, while the GE bit affects the execution of all tasks.

Setting exact match bits slows down execution time to something less than real time, but not as much as would single-stepping and executing a debugger's comparison code to trap data writes. The slowdown is about 25 percent, as compared with the several orders of magnitude resulting from single-stepping.

A final flag available in the control register, the GD bit, protects the debug registers from access in any processor

FIGURE 1: *Debug Control and Debug Status Registers*

DEBUG CONTROL REGISTER (DR7)

LEN 3	R/W 3	LEN 2	R/W 2	LEN 1	R/W 1	LEN 0	R/W 0	0	GD	0	GE	LE	G3	L3	G2	L2	G1	L1	G0	L0
31		23					15				7									0

LEN*n* BREAKPOINT *n* LENGTH: 00 = 1 BYTE
01 = 2 BYTES
10 = UNDEFINED
11 = 4 BYTES

R/W*n* BREAKPOINT *n* TYPE: 00 = INSTRUCTION
01 = DATA WRITE
10 = UNDEFINED
11 = DATA READ/WRITE

GD GENERATE INT 1 ON DEBUG REGISTER ACCESS
GE GLOBAL EXACT DATA BREAKPOINT MATCH
LE LOCAL EXACT DATA BREAKPOINT MATCH
G*n* ENABLE GLOBAL BREAKPOINT *n*
L*n* ENABLE LOCAL BREAKPOINT *n*

DEBUG STATUS REGISTER (DR6)

0	BT	BS	BD	0	B3	B2	B1	B0
31 23	15			7				0

BT TASK SWITCH (T BIT IN TASK STATE SEGMENT)
BS SINGLE-STEP (T BIT IN PROCESSOR FLAGS)
BD DEBUG REGISTER ACCESS (GD IN DR7 WAS SET)
B*n* BREAKPOINT *n* OCCURRED

Source: Intel Corporation

The debug control register, DR7, enables each of four breakpoint addresses and specifies the conditions under which each breakpoint occurs. After the breakpoint, the debug status register, DR6, indicates the reason for the interrupt.

mode at all levels of privilege. When this bit is set, an attempt to read or write any of the debug registers generates an INT 1. A debugger sets the GD bit in order to allow the debugger to reserve the registers for itself, preventing other programs from changing them. An INT 1 clears the GD bit, allowing the debugger's interrupt handler full access to the registers.

The GD bit is documented in Intel's advance-information data sheets for the 386; the current *Programmer's Reference Manual* does not mention it. The feature still works, however, on recent 16-MHz and 20-MHz versions of the chip. As with any undocumented feature, use it with caution as it may not be supported in the future.

All of the hardware-assisted debugging features of the 386 use INT 1 to invoke the debugger software. Also, as in previous Intel microprocessors, setting the single-step flag in the flags register generates an INT 1 after most instructions. This makes seven possible causes of INT 1: a breakpoint at any of the four addresses in registers DR0 through DR3; a task switch with the debug trap bit set in the TSS; an attempt to access the debug registers when the GD bit is set in DR7; or executing with the single-step flag set.

In order for the interrupt handler to distinguish among these possibilities, the hardware sets the appropriate bits in the debug status register, DR6, at each INT 1 (see figure 1). These bits are never cleared by the processor, so the interrupt handler must clear them before returning to ensure unambiguous determination of the cause of the next interrupt.

A breakpoint interrupt caused by an instruction fetch is a *fault*, meaning that the processor generates an interrupt before executing the instruction at the breakpoint address. At entry to the interrupt handler, the return address on the stack points to the instruction at the breakpoint address. When the interrupt handler returns, the processor again attempts to execute the same instruction; if the breakpoint is still active, this produces another interrupt. The INT 1 handler can disable the breakpoint, but a debugger often needs sticky breakpoints that remain in effect for a subsequent loop through the same code. The 386 hardware provides a convenient exit from this impasse.

In protected mode, an interrupt pushes the 32-bit flags register on the stack ahead of the return address. In the case of an INT 1, the processor sets the bit corresponding to the resume flag in the stack image of the flags. When the interrupt exits with the protected-mode version of IRET, the flags are restored from the stack, turning on the processor's resume flag. The purpose of the resume flag is to disable breakpoint faults for the duration of the next instruction only; the processor automatically turns off the resume flag after executing each instruction except for those that set the flags (IRET, POPF, and task-switching jumps and calls).

In real mode, an interrupt pushes only the 16-bit flags onto the stack, so a real-mode IRET does not affect the resume flag in bit 16 of the 32-bit EFLAGS register. A real-mode INT 1 handler, however, can set this flag by rearranging the stack to hold 32-bit versions of the flags and return address, and returning with an IRETD instruction instead of an IRET.

When a breakpoint occurs as the result of data access, the interrupt is a *trap*, occurring after the execution of the instruction that performs the access. If the GE or LE bits are set, the interrupt pushes onto the stack the address of the instruction following the instruction that trapped. Note that when a write breakpoint occurs, the target location has already been overwritten; if the original contents need to be preserved, the debugger should save the contents (in the same way that DEBUG saves the contents of locations where it inserts INT 3 instructions) before turning control over to the program under test.

These built-in debugging facilities do not replace the capabilities of an add-in hardware-assisted debugger. A hardware debugger allows the trapping of access to a broad range of memory, while the four built-in registers of the 386 processor can monitor a maximum of 16 bytes. Furthermore, an add-in hardware debugger can record a sequence of instructions or bus events that lead up to or follow a breakpoint. The 386 processor's inherent debugging support, however, allows the implementation of much more capable debugging software.

The DB386 sample program (listing 1) demonstrates how debugging software can use the debug registers.

The example is a terminate-and-stay-resident (TSR) program that adds instruction and data access breakpoints to any debugger that incorporates an INT 1 handler, for example, Microsoft's CodeView or SYMDEB, or DOS DEBUG. Its purpose is to demonstrate the principles of 386 debugging, not to implement a finished programmer's tool, so its user interface is a bit rough. Enhancing it with convenience features is a programming exercise that adds nothing to the understanding of the subject at hand.

To create DB386.COM, assemble the source with Microsoft's MASM or Borland's Turbo Assembler (both provide the required support of 386-specific instructions). Although debug registers can be used in real mode, both assemblers require the .386P (protected mode) directive to assemble this program. Microsoft's documentation does not mention this fact; in the MASM manual, instructions for moving to and from the 386 debug, test, and control registers are not on the list of instructions that require the protected-mode directive.

After assembly, link the program and convert it to a .COM file with EXE2BIN. Install it in memory by executing it from the DOS prompt. DB386 is an unusual TSR because it does absolutely nothing at installation; it hooks no interrupts and merely strands itself in memory. DB386 does, however, issue a message specifying its location, so you can subsequently access it with a debugger. Make a note of the two addresses (the data table and the go address) displayed at installation. For purposes of illustration, assume that the data table is at *xxxx*:100 and the go address at *xxxx*:*yyy*.

At the DOS prompt, start your favorite debugger and load a test program. Display the data table at *xxxx*:100. Into the first four double words of the table, enter the addresses of four breakpoints in the test program. These addresses should be in a segment:offset format; DB386 converts them into linear form before loading them into the debug registers.

Beginning at offset 110H, each paragraph contains an eight-character label followed by between two and eight bytes for entering debug control data. Beginning at offset 118H, enter eight bytes of data representing R/W0, LEN0, R/W1, LEN1, and so on through R/W3 and LEN3. At offset 128H, enter eight bytes of 0 or 1 representing L0, G0 through L3, and G3. At offset 158H, enter the address (in segment:offset format) of the point in the target program where the execution is to begin. Now, start execution at *xxxx*:*yyy*, the go address in DB386.

The go routine of DB386 loads the information from the data table into the 386 debug registers, repoints the INT 1 vector to an interrupt handler within DB386, then branches to the resume address in the target program. The branch is taken with an IRETD after arranging the stack for a 32-bit return that sets the processor's resume flag. This ensures that the instruction at the start address does not cause a debug fault, in case the target program is being restarted after a previous debug fault at the restart address.

When an INT 1 occurs, the handler in DB386 stores the debug status register into offset 148H of the data table, then chains through to the debugger's original INT 1 handler. There, the debugger handles the interrupt as a single-step breakpoint.

At this point, you can display the data table at *xxxx*:100 to see the reason for the interrupt. The two bytes at offsets 148H and 149H contain the two groups of bits from DR6, the debug status register. The first byte contains the four low-order bits that indicate whether or not a breakpoint occurred at one of the four addresses in the debug registers. The next byte contains the three bits that indicate the cause of the debug interrupt.

You may now use the debugger's commands to display memory, unassemble code, and change data, especially the debug data in the table at *xxxx*:100 within DB386. Even if you did not change any of the debug data, do not restart the target program with a **trace** command or **go** command with no start address. Instead, enter the resume address at *xxxx*:158 and restart execution from *xxxx*:*yyy*.

The reason for this action is twofold. First, if the interrupt resulted from an instruction fetch breakpoint, a plain restart triggers the same breakpoint again, whereas the go procedure of DB386 restarts the trapped instruction with the resume flag turned on. Second, most debuggers (including CodeView, SYMDEB, and DEBUG) recapture the INT 1 vector at every **trace** or **go** command, thereby bypassing the handler in DB386. To ensure that the debug status information is stored into the data table on the next interrupt, the procedure that repoints the vector to DB386 must be executed after the **go** command.

DB386 does not run in some protected-mode environments (such as Compaq's CEMM) that emulate EMS memory by turning on the 386 paging mode. This is because debug registers can be set only at privilege level 0 in protected mode. At the same time, these environments run DOS in virtual 8086 mode at privilege level 3. Some protected-mode environments (notably Microsoft Windows/386 and 386-to-the-Max from Qualitas) emulate real mode in the virtual 8086 space to such an extent that they allow access to the debug registers.

Qualitas's 386-to-the-Max does this by intercepting the protection exception from virtual mode, then parsing the instruction stream at the location where the exception occurred. If the exception is due to an attempt to access one of the special debug, test, or control registers, the protected-mode exception handler performs the access on behalf of the real-mode program; otherwise, it terminates the offender.

As mentioned, DB386 is merely a demonstration vehicle, not a practical debugging tool. With only moderate programming effort, however, it can be given a more convenient interface for entering and displaying the table of debug register data. Another enhancement would be to intercept keyboard input, automatically restart the target program through the DB386 go procedure in response to the **go** and **trace** commands, and pass all other input directly to the underlying debugger. This example purposely leaves out the complexities of a convenient user interface in order to concentrate on the interface between the hardware and software components of a 386 debugger. The ease of implementing this type of interface is a tribute to the design of this microprocessor.

LISTING 1: DB386.ASM

```
;*********************************************************************
; DB386 - Demonstration of 386 debug register usage
; Copyright (c) 1988 PC Tech Journal and Ziff-Davis Publishing Co.
; Written by Ted Mirecki
;*********************************************************************


; Macro to convert segmented address from dword at label DBREGx
; into a linear address, and load it into corresponding debug reg.


mov2dbreg  macro   XX
           xor     eax,eax
           mov     ax,word ptr dbreg&XX+2   ;get segment
           shl     eax,4
           mov     bx,word ptr dbreg&XX     ;get offset
           add     eax,ebx                  ;combine into linear addr
           mov     dr&XX,eax                ;load into debug reg
           endm

; Macro to concatenate bits of debug control data for DR7
; Builds r/w & length bits in AX, local/global bits in BX

setdr7     macro   xx
           mov     dx,word ptr rw&xx   ;len in DH, r/w in DL
           and     dx,303h          ;keep only 2 lo-order bits of each
           shl     ax,2             ;move previous bits
           or      al,dh            ;insert length bits
           shl     ax,2
           or      al,dl
           mov     dx,word ptr loc&xx  ;global flag to DH, local to DL
           and     dx,101h          ;keep only 1 bit of each
           shl     bx,1             ;insert into reg
           or      bl,dh
           shl     bx,1
           or      bl,dl
           endm

code       segment word public 'CODE'
           assume  cs:code, ds:code
```

```
;*********************************************************************
; Debug data table, to be filled in or read with the debugger.
; First 4 dwords hold addresses to be placed in DR0 thru DR3.
; Following paragraphs of table consists of 8 characters of text
; identifying the data in the next 2 to 8 bytes.
;*********************************************************************


           org     100h
dbreg0     label   dword           ;data overlays entry point
entry:     jmp     install
           org     104h
dbreg1     dd      0
dbreg2     dd      0
dbreg3     dd      0
           db      'R/W&LEN '
rw0        db      0
len0       db      0
rw1        db      0
len1       db      0
rw2        db      0
len2       db      0
rw3        db      0
len3       db      0
           db      'LOC/GLOB'
loc0       db      0
glob0      db      0
loc1       db      0
glob1      db      0
loc2       db      0
glob2      db      0
loc3       db      0
glob3      db      0
           db      'L/G EXAC'
loce       db      0
globe      db      0,0,0,0,0,0,0

           db      'BRKX,WHY'
statN      db      0
why1       db      0,0,0,0,0,0,0

           db      'GO ADDR '
resume     label   dword
```

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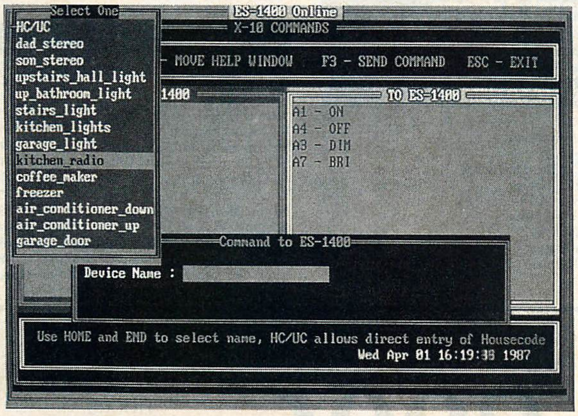

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```
resoff   dw      0
resseg   dw      0

old1     label   dword
old1off  dw      0
old1seg  dw      0
saveax   dd      0              ;storage for eax

;*******************************************************************
go  proc
    ;Loads data from table into debug registers, repoints INT 1,
    ;sets up stack for IRETD to set resume flag,
    ;branches to resume address in target program
;*******************************************************************

         .386p
         push    ebx
         push    dx
         push    ds
         push    es
         mov     cs:saveax,eax  ;save eax in lieue of push
         mov     ax,cs
         mov     ds,ax
         mov     ax,3501h       ;save INT 1 vector
         int     21h
         mov     old1off,bx
         mov     old1seg,es
         lea     dx,new1
         mov     ax,2501h       ;reset INT 1
         int     21h

         xor     ebx,ebx
         mov2dbreg 0            ;insert addresses into db regs 0-3
         mov2dbreg 1
         mov2dbreg 2
         mov2dbreg 3

         xor     ax,ax          ;construct control register dr7
         mov     bx,ax
         mov     bx,word ptr loce     ;loce->BL, globe->BH
         and     bx,101h              ;keep only 1 low bit of each
         shl     bl,7                 ;combine into BX bits 1&2
         shr     bx,7
         setdr7  3
         setdr7  2
         setdr7  1
         setdr7  0
         shl     eax,16         ;combine AX, BX into 32 bits
         or      eax,ebx
         mov     dr7,eax        ;load control register
         xor     eax,eax
         mov     dr6,eax        ;zero out status reg dr6

         pop     es
         pop     ds
         pop     dx
         pop     ebx
         pushfd                 ;get 32-bit flags into eax
         pop     eax
         or      eax,10000h     ;set resume flag
         push    eax            ;flags to stack
         push    0              ;set up stack for 32-bit iret
         push    cs:resseg      ;push 32-bit CS value
         push    0              ;push 32-bit IP value
         push    cs:resoff
         mov     eax,cs:saveax  ;all regs restored
         iretd                  ;go to resume address
go       endp
;*******************************************************************

new1     proc
    ; New INT 1 handler: stores debug status reg dr7 into data area,
    ; chains to original int 1 in underlying debugger
;*******************************************************************

         assume cs:code, ds:nothing
         sti
         push    eax
```

```
        mov     eax,dr6
        and     al,0Fh          ;low 4 bits: which break addr
        mov     cs:statN,al
        shr     ah,5            ;3 hi bits: reason for INT 1
        mov     cs:why1,ah
        pop     eax
        jmp     cs:old1
new1    endp

;*****************************************************************
install proc
  ; Print message & TSR without hooking anything
;*****************************************************************
        assume  cs:code, ds:code
        xor     ax,ax
        mov     ds:100h,ax      ;init start of data table
        mov     ds:102h,ax
        mov     ax,cs           ;convert addresses to characters
        lea     di,raddr$
        call    ax2hex
        lea     ax,dbreg0
        add     di,5
        call    ax2hex
        mov     ax,cs
        lea     di,gaddr$
        call    ax2hex
        lea     ax,go
        add     di,5
        call    ax2hex
        lea     dx,msg$         ;display message
        mov     ah,9
        int     21h
        lea     dx,install      ;TSR
        int     27h
install endp

msg$    db      'DB386 Copyright (c) 1988 '
        db      'PC Tech Journal and Ziff-Davis Publishing Co.'
        db      10, 13, 'Written by Ted Mirecki', 10, 10, 13
        db      'Register image table at '
raddr$  db      'xxxx:xxxx', 10, 13
        db      'Go address '
gaddr$  db      'xxxx:xxxx', 10, 13, '$'
code    ends

;*****************************************************************
; AX2HEX converts word in AX to 4 hex characters
;      Input: ES:DI -> 4-byte output string
;      AX destroyed, other regs preserved
;*****************************************************************
CODE       SEGMENT WORD PUBLIC 'CODE'
           ASSUME  CS:CODE
AX2HEX     PROC    NEAR
           PUSH    CX
           PUSH    DI
           MOV     CX,4            ;DIGIT COUNT
           CLD

NEXTBYTE:  ROL     AX,4            ;HIGH NIBBLE INTO LO 4 BITS
           PUSH    AX
           AND     AL,0FH          ;ISOLATE LOW-ORDER NIBBLE
           OR      AL,30h          ;CONVERT TO ASCII DIGIT
           CMP     AL,39h          ;ADJUST FOR DIGITS > 9
           JBE     STORIT
           ADD     AL,7            ;3AH -> 41h, ETC.
STORIT:    STOSB                   ;INSERT INTO STRING
           POP     AX
           LOOP    NEXTBYTE

           POP     DI
           POP     CX
EXIT:      RET
AX2HEX     ENDP
code       ends
           end     entry
```

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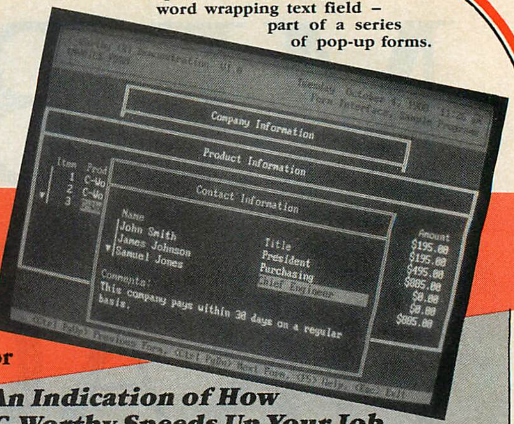

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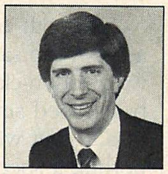

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What Do We Think We're Doing?

The events of 1988 suggest issues and strategies for developers in 1989. A lot of what will happen this year is up to you.

The past year, though discouraging in many ways, had a number of genuine bright spots. Among them, Ashton-Tate's dBASE IV finally shipped in late October, bringing a true applications perspective to a mature, mainstream tool. Competition in the critical area of applications technology has never been more vigorous; this is the first of three trends that I expect will affect the work of systems developers in the coming year.

The significant technical merits of dBASE IV were offset, unfortunately, by Ashton Tate's renewed insistence on its proprietary rights to the dBASE language—part and parcel of 1988's annoying level of litigation, the second trend of the coming year that causes me serious concern.

For language-level developers, a high-point of 1988 was the new Turbo Debugger from Borland. (A review of this product appears in "Turbo Debugging," Ben Myers, this issue, p. 46.) It borrows some of the most worthwhile innovations from decades of artificial intelligence (AI) research, the third trend bound to impact 1989.

WHEN APPLICABLE

I have a strong suspicion that the stratum of end users willing to learn generic computer skills is just about mined out. The number of people who regard personal computers as an intellectual challenge has long since reached saturation. The new challenge for developers, therefore, is to make these systems useful to people who find them no more intrinsically interesting than copiers or coffee machines.

Once, the image of the PC user was that of a technically inclined, young, single male with nothing better to do than patch files back together with an early edition of The Norton Utilities. Today, the user who matters is just like any other office worker, with a life and family off the job—for that matter, with a job in which PCs are a means to an end and emphatically *not* an end in themselves.

This puts a limit, therefore, on the continued success of horizontal tools such as spreadsheets—except, that is, to the extent that these tools can mature from ad hoc productivity tools into vehicles for the development of well-built local applications. Power users once made their contribution by being moment-to-moment consultants, able to penetrate obscure manuals or explain less-than-obvious features; today, the critical need is for the developer of departmental applications that turn general-purpose platforms into pieces of reliable, job-specific equipment.

The Ashton-Tate developers' conference last summer brought together many people with precisely this orientation. It was a fascinating group, with a keen sense of where they could make their best contribution. Take, for example, the team at Technicon Enterprises of Oley, Pennsylvania, that develops systems for maintenance of chemical plants and other process facilities.

When such a facility is shut down for a major repair, dozens (or even hundreds) of tasks must get done at the same time; these tasks are often performed to eliminate bottlenecks in the system that look individually trivial, but that actually control the total capacity of the plant. A shutdown, therefore, is a period of intensive activity, and this company's systems—based on dBASE and readily deliverable on a high-end, lunchbox portable—have eliminated days of costly orientation and tracking.

Another example is a team at Aetna Insurance who wanted to use scanned-document retrieval to reduce the physical movement of originals. Its initial research used an unusual tool: a camera, with which the team members took pictures of the actual work settings of their prospective users.

The Aetna team discovered that, in most cases, even conventional PCs and mainframe terminals were far away from the focus of the worker's attention. They found that the routine desktop clutter of calculators, writing tablets, and other paraphernalia was making computer-based support at best an auxiliary to the daily routine. They also found that, to be useful, a document-retrieval workstation would have to take on many other functions just to free up space on the desk. Aetna selected Quarterdeck's DESQview for this purpose.

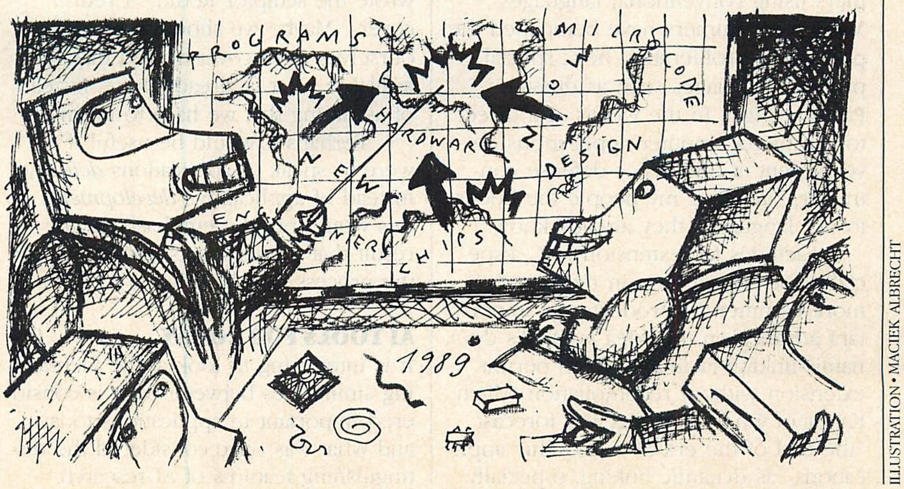

ILLUSTRATION • MACIEK ALBRECHT

In both cases, the result was to achieve the same kind of multiwindow workstation-class display that has been ballyhooed since the days of VisiCorp's VisiOn, but with a focus toward supporting a specific task or capability rather than just providing a technology-driven simulation of the real-life cluttered desk. This is what makes the difference between a productivity simulator, as multiwindow environments have been disparagingly called, and a workstation, with the emphasis on the *work* rather than the *station*.

EXTENDING THE REACH

The new dBASE template language, which functions as a translator between a high-level application-design environment and the rest of the system, was the most exciting feature of dBASE IV for many Ashton-Tate conference attendees. Using one of its predefined templates, dBASE IV can take the record of a design session and generate executable dBASE code; using another, it can take the same input and generate corresponding documentation for that design.

Because the template language is fully documented, some conference attendees immediately began to investigate the possibility of using the dBASE IV design environment to generate code in other languages as well. It would be interesting if dBASE IV became a universal application-design facility, with different back ends to deliver a given functionality on any language or platform. We can hope that other language developers, such as Borland and Microsoft, are also considering this notion of an applications designer as a front end to their own language products.

Also of note is the increasing emphasis on making off-the-shelf applications, such as word processors and spreadsheets, extensible by programmers using conventional languages. Many programmers have bemoaned the practice of proliferating new, special-purpose languages such as dBASE or Paradox's PAL. In the words of a director of microcomputer applications development at one major defense contractor, "Just give my people the hooks to use languages they already know."

Facilities for extension in C, especially, are showing up in more and more commercial products. An important advance on this idea is OS/2's dynamic-linking facilities, which permit extension without recompilation. Mitch Kapor of On Technology has forecast "the end of the era of monolithic applications" as dynamic linking, especially through object-oriented environments, becomes the norm. He foresees the ability to combine, for example, a word processor, a grammar and style utility, an E-mail facility, and a text-based index system for retrieval of related documents—all developed independently, but all working together as smoothly as if they had been designed as a single application.

DATA MINING

Although these new applications rely completely on the high level of interaction and the rapid, incremental development cycles that only a desktop machine can provide, they also rely increasingly on proper use of shared resources such as mainframe-resident data managers. Discussions with several of the attendees at *PC Tech Journal*'s Systems Forum '88 revealed that, in most cases, integration of existing systems and facilities is at least as important to their strategic direction as the development of new applications.

> *For language-level developers, a high-point of 1988 was the introduction of the new Turbo Debugger from Borland International.*

At the 1988 Personal Computing Forum in Naples, Florida, Kapor introduced the idea of data mining—an apt image, considering the vast (and vastly underused) collections of data that most organizations already have in one form or another. "I invent nothing," wrote the sculptor Rodin; "I rediscover." Maybe we should start to see ourselves as discovering and making available what is already there, instead of assuming that we have to invent it.

Perhaps it would be useful if we were to speak of applications *delivery* instead of applications *development*; this would put the emphasis on the result that the user gets, rather than on the process by which we produce it.

AI TOOLS FOR TODAY

It is interesting to look at the increasing similarities between what is considered important in applications today and what was once considered the distinguishing features of AI research.

Commercial applications used to run in batch mode—with highly structured input and on a very short leash in allowable memory and time—doing a job that remained the same for years at a time. By contrast, AI researchers built programs that had to be highly interactive, able to accommodate a wide range of input content and format, with access to relatively huge memory resources and CPU capacities (but with very short and highly iterative development cycles). The requirements I get from my users today certainly have a lot more in common with the second scenario than the first.

Consider a comment by John Seely Brown of Xerox at a Massachusetts Institute of Technology conference in 1984 (*The AI Business: The Commercial Uses of Artificial Intelligence*, MIT Press): AI has "consistently ignored the realities" of CPU cycles and memory, "focusing on what was possible rather than what was realistic," developing in the process "a powerful arsenal of programming tools that help manage the complexity of writing and experimenting with gigantic programs, programs constantly undergoing radical change."

Does this sound like your job? Could our community of business-applications delivery derive more immediate benefits from how AI developers have learned to work, rather than from what they have produced?

For example, a principal feature of interactive programming environments has been the Inspector, a resident debugging facility that gives internal visibility to any object in the system, whether code or data. Today, this facility appears in highly affordable tools such as Digitalk's Smalltalk/V series of development environments. Note that Digitalk now offers, for $500 per year, unlimited rights to generate stand-alone executable code from its base-level Smalltalk/V on DOS-based PCs; a slightly more complicated option permits delivery based on Smalltalk/V 286, which can address as much as 16MB of protected-mode memory on 286 and 386 machines (also under DOS).

Lest you dismiss any product based on Smalltalk as an educational toy, consider some of the real-world companies developing commercial products with Digitalk tools. Computer Sciences Corporation has a CASE tool called Design Generator, based on Smalltalk/V 286, that automates software specifications, analyzes them for completeness, and generates designs from those specifications. Computas Expert

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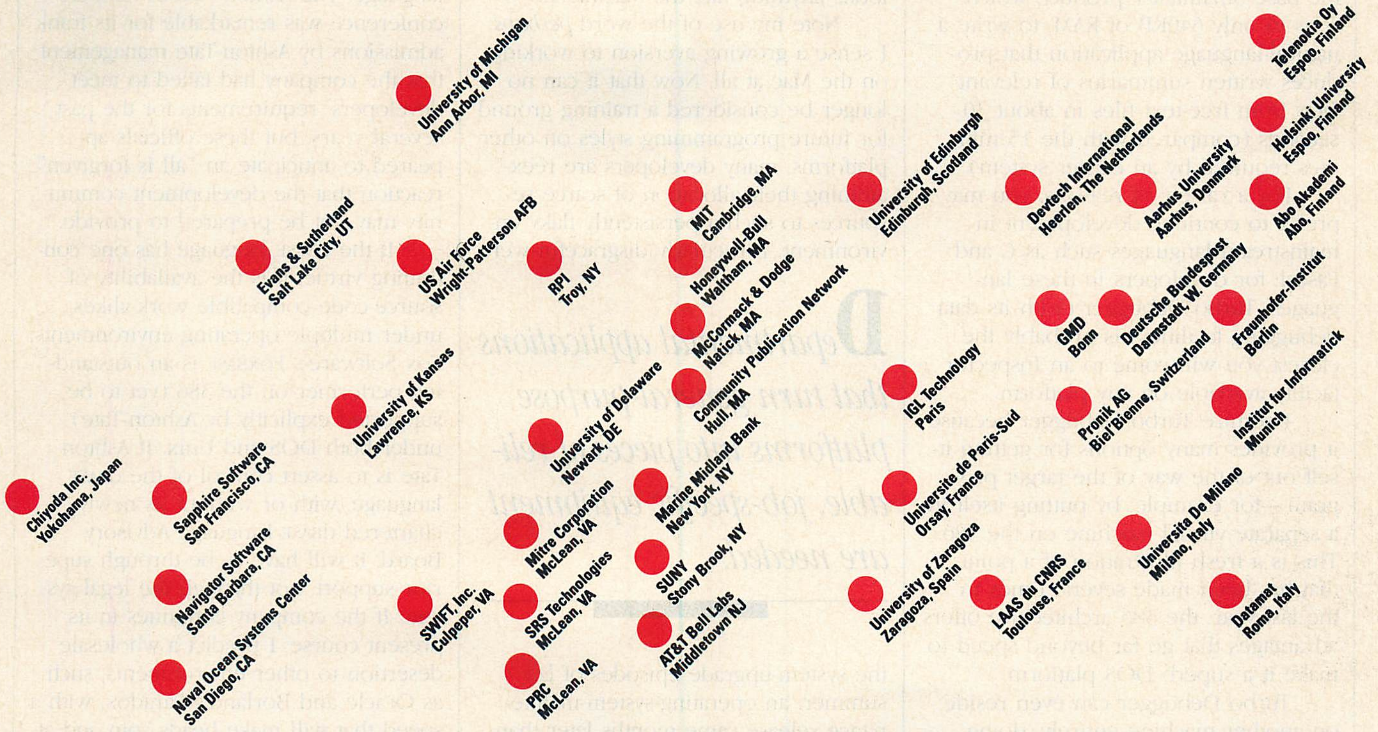

Honeywell-Bull, **Waltham MA**

Honeywell-Bull used Design/OA to create a graphical micro-computer interface to monitor their nightly mainframe batch processing. The application retrieves batch processing data, initiates the batch jobs, and provides the operator real-time processing status throughout the night.

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Systems has developed Steamex, a real-time energy-management system for steam production in industrial plants. Arthur Andersen & Company has used the base Smalltalk/V product, which runs in only 640KB of RAM, to write a natural-language application that produces written summaries of relevant facts from free-text files in about 30 seconds (compared with the 15 minutes required by an earlier system).

For a variety of reasons, you may prefer to continue development in mainstream languages such as C and Pascal; for developers in these languages, Turbo Debugger (with its data debugging facilities) is probably the closest you will come to an Inspector facility available on any platform.

I admire Turbo Debugger because it provides many options for getting itself out of the way of the target program—for example, by putting itself in a separate virtual machine on the 386. This is a fresh illustration of a point that has been made several times in the last year: the 386 architecture offers advantages that go far beyond speed to make it a superb DOS platform.

Turbo Debugger can even reside on another machine entirely, doing remote debugging through an external port using only a 15KB stub program on the target. Macintosh developers, saddled with an inadequate 128KB machine, got this feature at least four years ago; the 640KB space of DOS, especially after subtracting features such as network drivers, needs this facility just as much today.

WRITELNS, NOT WRITS

Much of what I like about the industry's current direction are not dramatic breakthroughs; most represent evolutions of good ideas, such as the Inspector, into workable implementations with much broader utility. I am alarmed, therefore, by the past year's trend toward litigation (or the threat thereof) as a competitive tool, creating an atmosphere that discourages successful incremental refinement.

The Apple lawsuit against Hewlett-Packard and Microsoft, for example, is still slouching its way through the legal system and creating continuing uncertainty as to what the mainstream graphics user interface will look like years from now. I specifically wish to suggest that this mainstream interface will not look that much like the present-day Macintosh. Apple has effectively hung a bag of garlic around the neck of its bundle of interface conventions disguised as a copyrightable work. No sane developer would go near a software project (except, perhaps, on Apple hardware) with an interface that looks anything like the Macintosh.

Note my use of the word *perhaps*. I sense a growing aversion to working on the Mac at all. Now that it can no longer be considered a training ground for future programming styles on other platforms, many developers are reexamining their allocation of scarce resources to such a persistently flaky environment. Particularly disgraceful were the system-upgrade episodes of last summer: an operating-system-maintenance release came months later than expected and was followed within a couple of weeks by a fix for an entirely new and serious bug that was created during those repairs.

Departmental applications that turn general-purpose platforms into pieces of reliable, job-specific equipment are needed.

The design compromises of the tightly bottlenecked NuBus in the Macintosh II became apparent as soon as the first accelerator boards came on the market; second-generation Macintosh platforms show every likelihood of being thoroughly orphaned within a year or two, and many users see the first generation as being effectively orphaned already.

The Macintosh virtue of a flat, expandable memory space has actually become a curse for low-budget users who feel they are being rapidly abandoned by developers who now expect 2MB or more for useful performance. DOS's 640KB straitjacket has at least forced the DOS community to stretch the range of its platforms, rather than merely sliding it higher and higher.

Every developer has to consider a potential target platform in terms of its role in the marketplace, which does not permit neat categorization of pros and cons, but demands that they be considered all at once. The Apple lawsuit combines nonlinearly with Apple's technology decisions to create a climate in which the Mac represents a risk for user and developer alike.

Equally annoying is Ashton-Tate's insistence that, with the release of dBASE IV, it is now morally entitled to reassert legal ownership of the dBASE language. The Ashton-Tate developers' conference was remarkable for its frank admissions by Ashton-Tate management that the company had failed to meet developers' requirements for the past several years, but these officials appeared to anticipate an "all is forgiven" reaction that the development community may not be prepared to provide.

If the dBASE language has one continuing virtue, it is the availability of source-code compatible work-alikes under multiple operating environments; Fox Software's FOXBASE is an outstanding performer on the 386 (yet to be supported explicitly by Ashton-Tate) under both DOS and Unix. If Ashton-Tate is to assert control of the dBASE language, with or without its newly chartered dBASE Language Advisory Board, it will have to be through superior support, not through the legal system. If the company continues in its present course, I predict a wholesale desertion to other environments, such as Oracle and Borland's Paradox, with a speed that will make heads spin and at a cost that will make heads roll.

THE CHALLENGE OF CHOICE

In the movie "Cannonball Run," a race driver removes his rearview mirror, explaining, "What's behind me doesn't matter." If only we could enjoy such a simple perspective. But, the events of the spring of 1987—PS/2, OS/2, and Macintosh II—were not isolated bursts of noise. Rather, they were the beginning of a state of near chaos that continued through 1988 and shows no sign of abating.

It is no longer practical to equip users with a single mainstream platform that is virtually guaranteed to support every worthwhile innovation as soon as it appears. The challenge of systems integration and development today is to know what's needed now and to envision what will be useful tomorrow, and to determine which options can be safely foregone today to meet those needs in a timely and cost-effective manner. As this column enters its second year, I hope we can help each other do exactly that.

Peter C. Coffee is managing partner of SolveWare, a developer and business computing consultant, and is active in AI and distributed computing applications for aerospace and educational clients.

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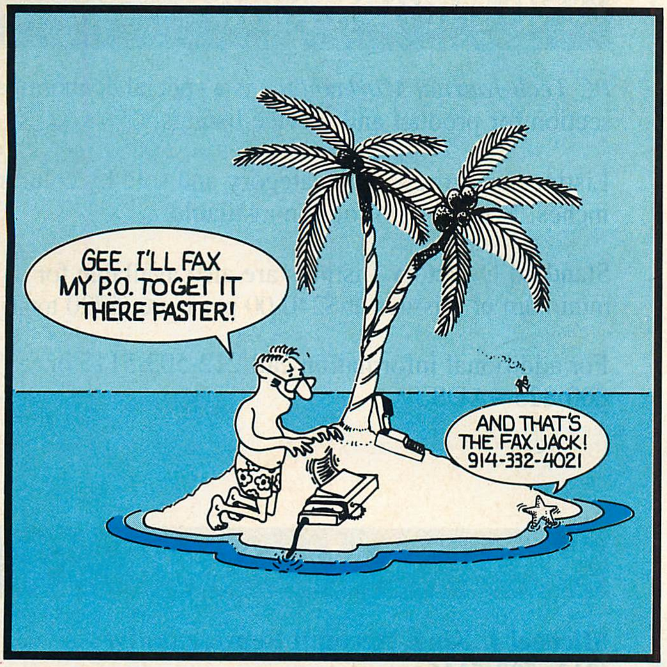

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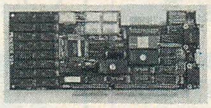

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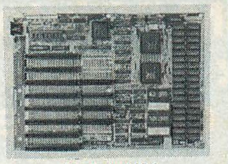

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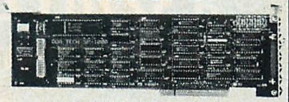

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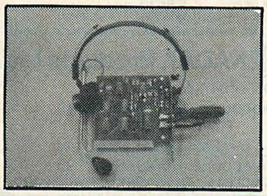

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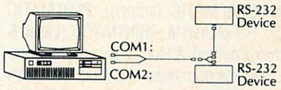

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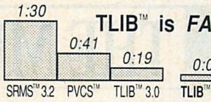

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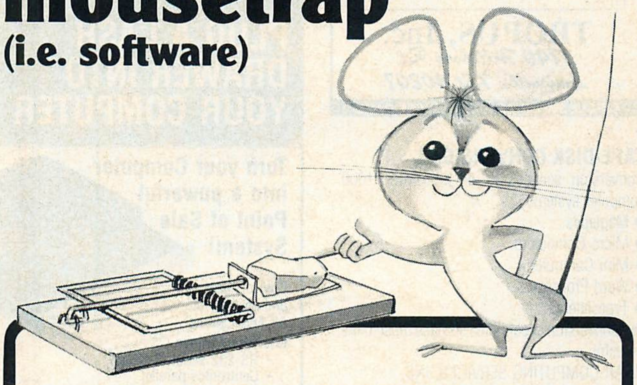

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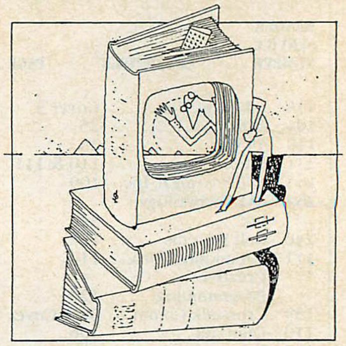


Favorite computer books include those about DOS, C, general programming, and OS/2.

DOS, C, general programming, and OS/2 are popular book topics, according to an informal *PC Tech Journal* reader opinion poll that asked, "What is the best computer book you've read recently?"

The preference for tutorials on these subjects reflects our readers' constant striving to learn better ways of building their applications.

READER PICKS

DOS books that respondents recommend include *DOS Power Tools* (Paul Somerson, 1988) and *Advanced MS-DOS* (Ray Duncan, 1986). "[*DOS Power Tools* is] the best all-around guide for both new users and pros," says Paul Billingslea, president of P.C. Solutions.

Louie McCrady, president of Endeavour Development Company Limited, wishes he had *Advanced MS-DOS* four years ago. "It would've saved me hundreds of hours searching for the information in 10 other books."

Running MS-DOS (Van Wolverton, 1988) is a good book for consultants to recommend to newcomers; *Taming MS-DOS*, second edition (Thom Hogan, 1988) is "easy to understand" and "has lots of examples and source code;" and *Performance Programming Under MS-DOS* (Michael Young, 1987) is for "programmers who want a technical and practical approach."

Book lovers recommend many C titles, including *C Programming Language*, second edition (Brian Kernighan and Dennis Ritchie, 1988). "It's the bible!" says Mike Blaszczak, technical representative of Networking and World Information.

Of Robert Ward's *Debugging C* (1986), Michael Singer, senior programmer/analyst at Dialcom, says, "It is an excellent guide to a neglected but real part of software development."

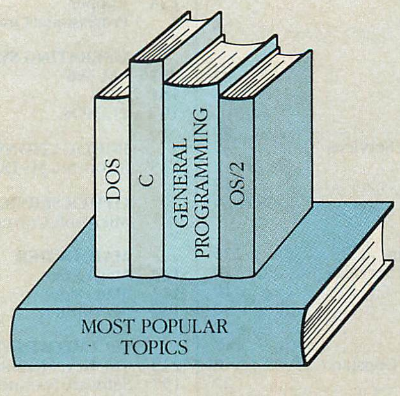
The *C Programmer's Guide to Serial Communications* (Joe Campbell, 1987) describes "how and why serial communications work;" readers say *C Primer Plus* (Michael Waite, Stephen Prata, and Donald Martin, 1987) is best for learning C; and *Advanced C* (Paul and Gail Anderson, 1988) "really goes beyond the basics." Similarly, *Turbo C DOS Utilities* (Robert Alonso, 1988) "shows the many possible ways to access DOS with Turbo C;" and *Turbo C Programming for the IBM* (Robert Lafore, 1987) "is clear, concise, interesting, humorous, and lively."

Readers value Charles Petzold's *Programming Windows* (1988). Consultant Chris Hawkins of Ravenna Software, says, "It cuts the Windows learning curve in half."

About Thom Hogan's *Programmer's PC Sourcebook* (1988), John Switzer, director of technical support for Manzana MicroSystems, says, "It's the most complete reference to date on pinouts, DIP switches, jumpers, cabling, and BIOS interrupts."

Respondents say the *Programmer's Guide to IBM PC and PS/2* (Peter Norton, 1988) provides technical meat without the technical reference document; *The Mythical Man-Month* (Frederick P. Brooks, Jr., 1974) is "required reading for anyone involved in large software projects;" *Programming Pearls* (Jon Bently, 1986) "challenges your mind;" and the three-volume classic, *The Art of Computer Programming* (Donald Knuth, 1973, 1974, and 1981), is a must-have bookshelf reference.

What is the best computer book you've read recently?



OS/2 is garnering attention in the book world. J. F. Gilliland, manager of tax systems, BP America, considers Gordon Letwin's *Inside OS/2* (1988) to be "the best book for understanding the whys and wherefores of OS/2."

Adam Martinez, director of PC services, Bolt Systems, says Ed Iacobucci's *OS/2 Programmer's Guide* (1987) is "an excellent introduction to programming for OS/2." Finally, *OS/2: Features, Functions, and Applications* (Jeffrey Krantz, Ann Mizell, and Robert Williams, 1988) is a book that "deals with OS/2 without overdoing tables and figures."

Two other topics on computer reading lists are graphics and data management. The *Programmer's Guide to PC and PS/2 Video Systems* (Richard Wilton, 1988) is recommended for completeness, accuracy, and technical detail. Alan Simpson's *dBASE III PLUS Programmer's Reference Guide* (1987) reportedly can convert a novice into an expert dBASE programmer. Also, Simpson's *Understanding dBASE III PLUS* (1986) is "intelligent, easy to follow, and thorough."

TURNING THE PAGES

In judging computer books as valuable, our readers used these primary criteria: technical depth; insight; concise writing; completeness; accuracy; and clear organization. Above all, a good computer book delivers an approach or technique that readers can apply to applications. In the words of American teacher and philosopher Amos Bronson Alcott, a good book "is opened with expectation and closed with profit." It is for this reason that these books are in our readers' libraries.

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c ☐ Own Company
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3 Is your purchase involvement:
e ☐ Company-Wide
f ☐ Division-Wide
g ☐ Departmental

4 Number of employees in your company:
h ☐ 25 or Less
i ☐ 26-99
j ☐ 100-499
k ☐ 500-999
l ☐ 1000 or More

5 Are PCs within your company used for:
m ☐ Programming
n ☐ Data Management
o ☐ LANS
p ☐ Host/Communications
q ☐ Programming Languages/Tools

6 Are you planning to purchase in the next 6 months:
r ☐ Programming Languages/Tools
s ☐ Data Management Software
t ☐ LANS
u ☐ Host Communications
v ☐ Operating Environments
w ☐ Computer Systems

7 What is your primary job function? (Check one)
x ☐ Systems Design/Integration/Analysis
y ☐ Data Communications
z ☐ Outside Consulting
1 ☐ DP/MIS Management/Operations
2 ☐ Programming
3 ☐ Software Engineering
4 ☐ Inside Consulting
5 ☐ Hardware Engineering

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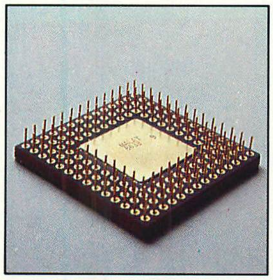

Being the first to use the 80386 chip, we established one fact.

The Newspaper for the Microcomputing Community

InfoWorld

Volume 8, Issue 28

July 14, 1986

Special Report: PC, AT Clones
See Page 29.

Fast and Easy Mac Accounting
See Review, Page 49.

Micropro To Market Desktop Program

By Karen Sorensen and Laurie Flynn
InfoWorld Staff

SAN RAFAEL, CA — Micropro International Corp. announced plans to develop, in conjunction with Island Graphics Corp., a Wordstar-compatible IBM PC desktop publishing program that will operate under Microsoft Corp.'s Windows.

The agreement between Micropro and Island of Sausalito, California, gives Micropro exclusive worldwide retail marketing rights to the product, code-named Prism. Micropro said it expects to ship the product by the end of 1986.

Prism will accept text files from Micropro's Wordstar, Wordstar 2000, and Easy word processing programs, as well as those conforming to IBM's Document Content Architecture protocol, according to H. Glen Haney, president of Micropro. A limited ... editor will be incorporated into the ... the user can manipulate text ...

Gene Lu, president of Advanced Logic Research (left), and Dave Kirkey, vice president of sales and marketing, display the company's 80386-based prototype.

MIKE PILGRIM

First Micro To Employ 80386 Chip Due in Fall

By Priscilla M. Chabal and Elizabeth Ranney
InfoWorld Staff

IRVINE, CA — Hardware maker Advanced Logic Research Inc. said it is poised to beat IBM Corp. and other major players to market with a microcomputer based on Intel Corp.'s next-generation 80386 microprocessor.

The computer, the Access 386, will use a recently announced 80386 BIOS from Phoenix Technologies Ltd. of Norwood, Massachusetts, and will be compatible with the IBM PC AT, according to Gene Lu, Advanced Logic's president. The machine, which is being manufactured for the company in Singapore, will use the MS-DOS 3.2 operating system and allow software written for the current 286 chip to run three to four times faster, the company said. The machine will be equipped with a 40-megabyte hard disk drive and a proprietary video graphics card.

The company said the machine is slated to be on the market by the fourth quarter this year and is expected to be priced between $7,000 and $8,000.

IBM and Compaq Computer Corp., both reported to be working on 80386-specific machines, are not expected to announce them until sometime in 1987.

Although there is no 80386-specific version of MS-DOS that would allow software to take advantage of many of the advanced chips features, Lu said the machine will nonetheless outperform an ... appeal to users whose programs ...

Continued on Page 8

California Legislator Backs Off
ffort to Pass Warranty Bill

... in early 1987 if she isn't satisfied with the ... efforts by then.
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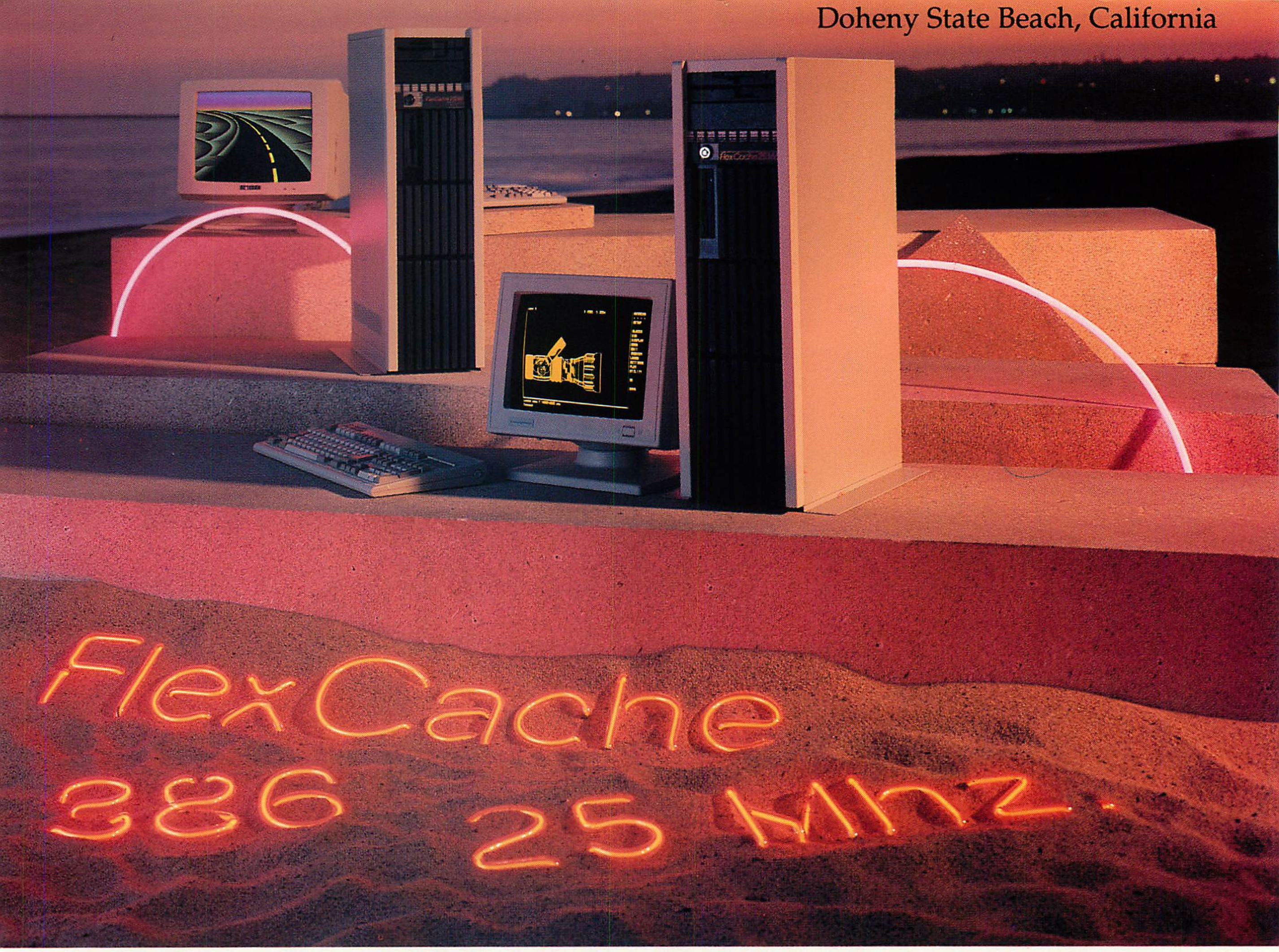

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PC Lab Benchmarks 80286 Instruction Mix - Seconds	**2.75 SEC.**	**4.56 SEC.**	**7.20 SEC.**	**2.20* SEC.** *80386 Instruction Mix	**2.36* SEC.**
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Memory (RAM)	1MB (80ns)	1MB (100ns)	1MB (85ns)	2MB (60ns)	2MB (80ns)
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* Prices and configurations as of August 1988 and subject to change.

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